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R. Kaveé

some 'short cut'

Statistical Methods

by MONROE

MONROE
SHORT-CUT
STATISTICAL METHODS

Some Short-cut

STATISTICAL METHODS

for

MONROE ADDING CALCULATORS

Model CAA-10

And

Model CAA-10-3-S

Published by

MONROE CALCULATING MACHINE COMPANY, INC.

GENERAL OFFICES · ORANGE, NEW JERSEY

Branch Offices in All Principal Cities

Form 1038-S

Printed in U.S.A.

FOREWORD

The purpose of this booklet is to provide statisticians and all those employing statistical methods, with a manual which will furnish some short-cut methods for applying the Monroe to statistical computations. These methods and the use of the Monroe CAA-10 or CAA 10-3-S (Statistical Model) will reduce the tedious task of computing statistical data by minimizing the use of data sheets and the recording of intermediate steps. As a result, much time can be saved and the chance of error that occurs in copying and recopying results of intermediate steps eliminated.

This booklet is not intended to be an exhaustive textbook, nor does it include the only possible methods for performing statistical computations on the Monroe. It was written, however, to suggest general methods which can easily be adapted to meet the requirement of the particular problem at hand. Several of the applications included in this booklet were developed from information and suggestions given to the Monroe Calculating Machine Company, Inc. by users of its equipment. Monroe welcomes any further suggestions which may prove of value to others working in the field of statistics.

Simple data was employed throughout this booklet, to illustrate the general nature of the computations involved. No attempt has been made to interpret results. Some figures have been carried out to a greater number of decimal places than required in everyday practice merely to demonstrate the degree of accuracy obtainable on the Monroe. Problems consisting of more extensive data are handled in the same manner as those illustrated. The only difficulty may be in exceeding the capacity of the machine. In cases such as this, the problem can be broken down into parts which will not exceed the capacity of the machine. These parts are then combined in order to compute the final result.

In addition to statistical applications, this booklet contains pictures of the Monroe CAA-10 and the CAA-10-3-S (Statistical Model) as well as a description of all of the features and operating controls. Basic instructions in addition, subtraction, multiplication, division, and squaring a number, have also been included for easy reference. Since square roots are necessary in many statistical applications, an appendix is included setting forth an accurate method for obtaining the square root of a number to eight significant digits on the Monroe.

Other pamphlets and articles published by Monroe, which may be of value in statistical computations are:

Form #992-S	Quality Control Booklet
991-S	Square Root Factors, Division, Accurate to five significant digits
994-S	Square Root Factors, Multiplication, Accurate to five significant digits
XSS-193	"A Short Method of Evaluating Determinants"
XSS-385	Monroe Method of Matrix Solution
XSS-393	The Tape Adding Machine Aids Statistical Calculations

This and other instructional material can be obtained from your local Monroe representative.

If any further information pertaining to statistical applications is required, it may be obtained by writing directly to Monroe Calculating Machine Co., Inc., Orange, New Jersey.

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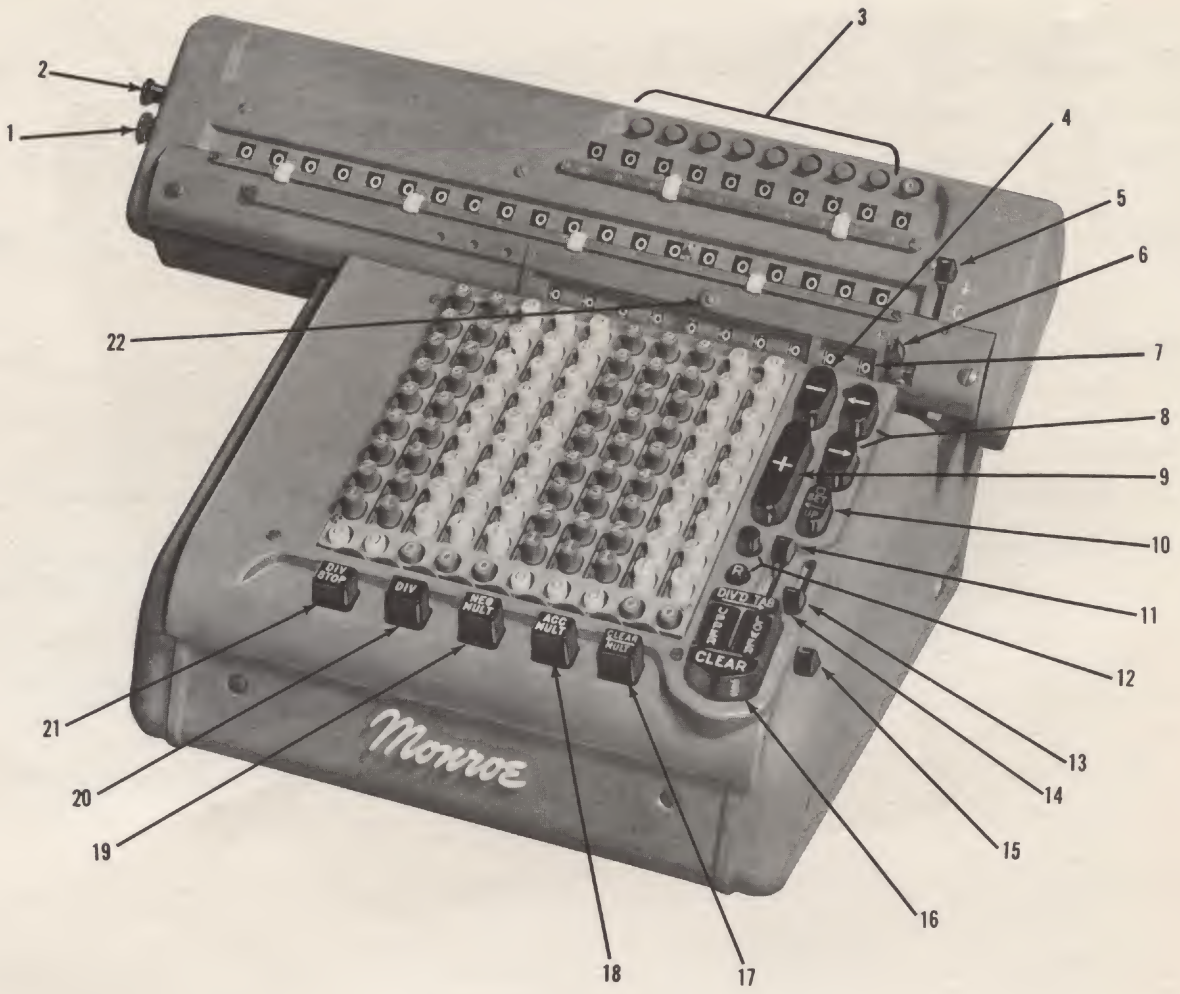

MODEL CAA-10 MONROE ADDING CALCULATOR

1 Lower Dials Lock

2 Upper Dials Lock

3 Tab Stops

4 Minus Bar

5 Constant Multiplier Lever

6 Transfer Lever

7 Multiplier Set-Up Dials

8 Carriage Shift Bars

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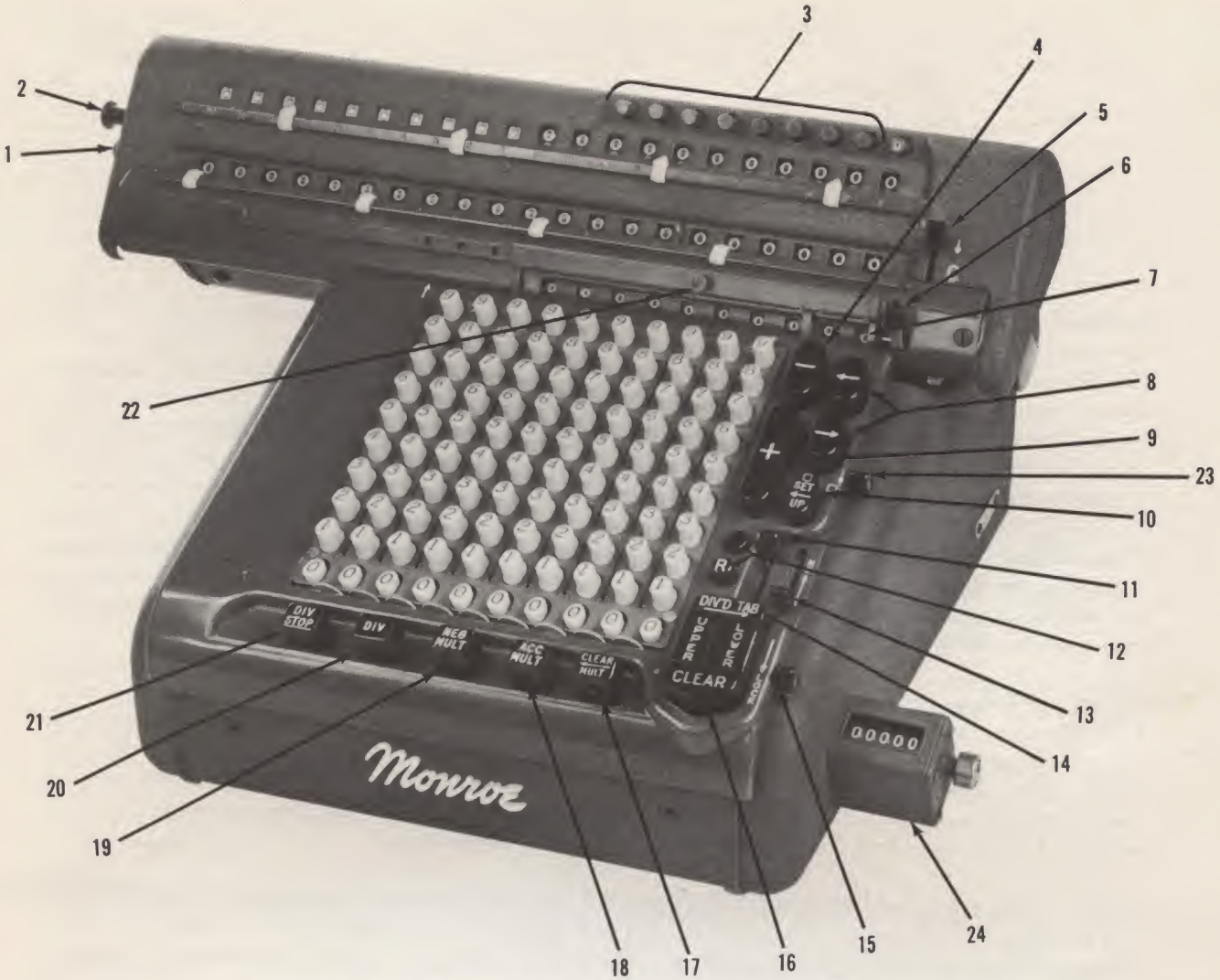

MODEL CAA-10-3-S MONROE STATISTICAL CALCULATOR

1	Lower Dials Lock	9	Plus Bar	17	Clear, Return and Multiply Key
2	Upper Dials Lock	10	Set-Up and Squaring Key	18	Accumulative Multiply Key
3	Tab Stops	11	Change Lever	19	Negative Multiply Key
4	Minus Bar	12	Repeat and Non Repeat	20	Divide Key
5	Constant Multiplier Lever	13	Non-Entry Lever	21	Divide Stop Key
6	Transfer Lever	14	Dividend Tab Key	22	Slide
7	Multiplier Set-Up Dials	15	Change Lever Lock	23	Squaring Lock
8	Carriage Shift Bars	16	Clear Keys	24	Veeder Counter

MODEL CAA-10 and MODEL CAA-10-3-S

OPERATING CONTROLS

Keyboard Like all Monroe Adding-Calculators, the Monro-matic has a full, standard, flexible type keyboard. The zero key at the base of each row is generally used to clear any depressed key in its row. By means of the zero keys, it is possible to retain any amount set on the keyboard so it is locked against normal clearance. To lock an amount the operator first sees that the repeat key is down, then holds down each zero key simultaneously while depressing each of the figures of the amount. The amount so locked will, however, be cleared if the set-up key or dividend tab key is depressed. A locked figure is released by setting another figure in the same column and depressing the clear key.

Plus and Minus Bars The plus and minus bars (9 and 4 in illustration) are used for addition and subtraction respectively and in semiautomatic operation for multiplication and division. For adding and subtracting, the non-repeat key is usually depressed and the keyboard clears automatically so that a single addition or subtraction of each item is performed.

Repeat and Non-repeat Keys (12) When the lower of these two keys, marked R, is depressed, any keys depressed on the keyboard remain set until cleared by the operator or until they are automatically cleared through the fully automatic operation of the machine. In semiautomatic multiplication and division the R key should be depressed. When the upper key is depressed the keyboard clears after each cycle of the machine. In fully automatic operation the operator does not have to change the setting of these keys; they are used only when adding and subtracting.

Dials The upper dials (right upper dials on the CAA-10-3-S) show the multiplier in multiplication and the quotient in division; they have the carry-over feature, thus registering a true count above 9. The lower dials register results in addition and in multiplication, the remainder in subtraction, and the dividend in division.

Series 3 Dials The left upper dials on the CAA-10-3-S show the multiplier in multiplication and the quotient in division; they do not have the carry-over feature.

Dial Locks The two small knobs on the left side of the carriage control the clearance of the upper and lower dials. The upper knob (2), controls the upper dials; when pushed in towards the carriage, the upper dials can be cleared; when pulled out, figures in the upper dials are retained. The lower knob (1) which controls the lower dials, has three positions. When all the way in, the lower dials can be cleared, and when pulled all the way out, the lower dials are locked against clearance. The third position, when the knob is half-way, is provided for split dials operation; when in this middle position, all the lower dials from the ninth to the first inclusive on the right are locked against clearance, while all the dials from the tenth to the last inclusive on the left can be cleared. The Series 3 dials on the CAA-10-3-S cannot be locked against clearance at any time.

Change Lever The action of the change lever (11) which controls the direction of rotation of the upper dials, is automatically regulated by the machine in fully automatic operations so that answers in the upper dials are always given in true figures. Normally the change lever is in the upper or X position for multiplication and in the lower or ÷ position for division. For special applications it can be locked in either position by pulling down the small metal lever (15) located at the right of the clear keys.

Carriage Shift Bars (8) In fully automatic operations the carriage of the Monro-matic shifts automatically. At other times when the carriage is to be moved, depressing either of the shift bars located at the right of the plus and minus bars shifts the carriage in the direction that is indicated by the arrow on the bar.

Depression of the upper shift bar shifts the carriage to the left.

Depression of the lower shift bar shifts the carriage to the right.

Multiplier Set-Up Dials These dials (7) store multipliers that are used in automatic multiplication. Multipliers enter the set-up dials from either the keyboard or the lower dials.

Constant Multiplier Lever When this lever (5) is moved down it locks the amount in the multiplier set-up dials so it is retained as a constant multiplier. The constant is released by moving the lever up before depressing the multiplier key on the last multiplication in which the constant is required. When the constant lever is down no figures can be entered in the multiplier set-up dials.

Set-up and Squaring Key 

A depression of the set-up key (10) transfers the keyboard amount into the multiplier dials when the carriage is in any position. When the carriage is in any other but the first position, depressing the set-up key will also return the carriage to the first position or to a tab stop position. Another function of the set-up key is that it serves as a squaring lock. When depressed and held down until the set-up action is fully completed the keyboard amount will transfer into the multiplier set-up dials and will still remain on the keyboard.

Note: On some CAA calculators this key is marked "ENTER X".

Squaring Lock The squaring lock (23) on the CAA-10-3-S controls the action of the set-up key (10). When this lever is in the downward position the lock is on and numbers set *on* the keyboard remain there for squaring following all depressions of the set-up key. When the lever is in the upward position the lock is released restoring the normal action of the set-up key.

Clear, Return, and Multiply Key 

When the carriage is in the first position, depressing this key (17) clears the upper and lower dials and multiplies the amount set on the keyboard by the amount in the set-up dials. At the completion of the multiplication, the keyboard clears and the carriage returns to either the first position or to a tab stop position; the multiplier shows in the upper dials and the product is read in the lower dials. If the carriage is in any but the first position when this key is depressed, it returns to the first or a tab stop position and both dials clear. In transfer operations the depression of this key transfers the lower dials amount to the set-up dials if the transfer lever has been shifted to the left.

Non-entry Multiplier Control When it is desired not to have multipliers or other plus counts register in the upper dials, moving the non-entry lever (13) *up* stops figure entry in the upper dials. In certain operations, such as discount work, when the non-entry feature is being used and it is necessary to lock the change lever in the X position, moving the change lever *down* normalizes the non-entry multiplier control. To change back to using the non-entry feature, the non-entry multiplier control is moved up, which also releases the change lever lock.

Accumulative Multiply Key 

When this key (18) is depressed the amount on the keyboard is multiplied by the amount in the multiplier set-up dials without dials clearance or automatic carriage return. Upon completion of the multiplication, the keyboard clears automatically. This key is provided for accumulative multiplication and can be used only with the carriage in the first position.

Negative Multiply Key 

The negative multiply key (19) also can be used only when the carriage is in the first position. When it is depressed the amount on the keyboard is negatively multiplied by the amount in the multiplier set-up dials, but the machine does not clear automatically nor is the carriage returned. In automatic negative multiplication the amount in the multiplier set-up dials is transferred to the upper dials negatively unless the change lever is in ÷ position.

Divide Key 

The automatic divide key (20) operates with the carriage in any position and when depressed the amount on the keyboard is automatically divided into the amount in the lower dials, the answer appearing in the upper dials. At the completion of the division the keyboard is automatically cleared.

Stop Key 

Fully automatic division on the Monro-matic can be stopped at any point desired by simply depressing this key (21); when the machine stops dividing the keyboard clears.

Clear Keys 

In operations when the dials are not cleared automatically, manual clearance is performed by means of the group of three keys (16). All these keys are electrically operated, hence require but a slight fingertip pressure and can be depressed either separately or jointly. The key marked UPPER clears the upper dials; the one marked LOWER clears the lower dials; and the bottom one marked CLEAR is the master clear key for the entire keyboard.

Dividend Tab Key Depression of the dividend tab key (14) causes the machine, in one automatic and continuous operation, to clear the upper and lower dials, shift carriage to either the tenth or a tab stop position, enter the keyboard amount into the lower dials, clear the "1" from the upper dials, and clear the keyboard.

Slide The slide that is located directly above the multiplier set-up dials can be moved to the right or left by first pulling out the knob (22) and shifting the slide into the desired position and finally seating the knob. The position of the slide is indicated by the arrow over the red bar. The principal functions of the slide are to shift the carriage into the proper transferring position following an automatic multiplication and to tabulate the carriage with or without the use of tab stop keys.

Transfer Lever The transfer lever (6) is only used when the carriage is out of the first position. It is moved manually by the finger to the left as far as possible. Then depression of the clear return and multiply key automatically transfers the lower dials amount into the multiplier set-up dials.

Tab Stops When any of the eight tab stops (3) is depressed it predetermines the carriage position in automatic multiplication and division. They are used in conjunction with the dividend tab key, clear return and multiply key, carriage shift bars, and slide. They stop the carriage when it is shifting in either direction. When it is desired to use two tab stops, the keys should be depressed simultaneously. Tab stop keys that are down can be cleared by depressing the extreme right hand key marked 0.

Veeder Counter The Veeder Counter (24) on the CAA 10-3-S is located on the right side of the machine. This counter will register each depression of the Clear, Return, and Multiply key (17).

DECIMAL SETTING

Monroe Rule:

Keyboard decimal + upper dial decimal = lower dial decimal.

This one simple rule for setting decimals is used on all Monroe calculators. If it is followed, results will be produced around the correct, pre-set decimal markers. The simplicity of the Monroe decimal system will soon banish from the operator's mind, the idea that decimal setting is complicated and difficult.

Following are some pointers which will aid the operator to examine the work at hand and pre-set the decimal system to handle it.

Addition and Subtraction:

Keyboard	Set decimal to handle largest number of decimal places in the numbers to be added.
Upper dials	Decimal is at zero.
Lower dials	Set decimal same as keyboard Keyboard decimal + upper dial decimal = lower dial decimal.

Multiplication:

Keyboard	Examine the multiplier and multiplicand, and determine which has the larger number of decimal places. Set the keyboard decimal to accommodate this number of decimal places.
Upper dials	Set decimal same as keyboard
Lower dials	Keyboard decimal + upper dial decimal = lower dial decimal.

Division:

Keyboard	Examine the divisor and dividend and determine which has the larger number of decimal places. Set the keyboard decimal to accommodate this number of decimal places.
Upper dials	Always decide how many decimal places are required in the answer and set the decimal to one more than this. (To permit rounding off).
Lower dials	Keyboard decimal + upper dial decimal = lower dial decimal.

ADDITION

Example:

24.3602
13.451
67.3214
105.1326

Program:

Upper dials	0	Non-repeat key depressed
Keyboard	4	
Lower dials	4	

Step 1. With carriage in the 1st position set 24.3602 on the keyboard at the 4th decimal. Depress the PLUS BAR once.

Step 2. Set 13.451 on the keyboard. Depress the PLUS BAR once.

Step 3. Set 67.3214 on the keyboard. Depress the PLUS BAR once.

Result in lower dials 105.1326
Result in upper dials 3 (number of items added)

SUBTRACTION

Example:

16.950
-13.214
3.736

Program:

Upper dials	0	Non-repeat key depressed
Keyboard	4	
Lower dials	4	

Step 1. Set 16.950 on the keyboard at the 4th decimal. Depress PLUS BAR once.

Step 2. Set 13.214 on the keyboard. Depress MINUS BAR once.

Result in lower dials 3.736

MULTIPLICATION

Example:

67.322 × 1.53 = 103.003

Program:

Upper dials	4
Keyboard	4
Lower dials	8

Step 1. Set 1.53 (number with least number of digits) on the keyboard. Depress SET UP key.

Step 2. Set 67.322 on the keyboard. Depress the CLEAR MULT key.

Result in lower dials	103.003
Result in upper dials	1.53

DIVISION

Example:

219.65 ÷ 14.325 = 15.3333

Program:

Upper dials	4	Tab	5
Keyboard	4		
Lower dials	8		

Step 1. Set 219.65 on the keyboard at 4th decimal. Depress DIVD TAB key.

Step 2. Set 14.325 on the keyboard. Align left hand digit in the upper dials with the left hand digit on the keyboard. Depress the DIV key.

Result in upper dials	15.3333

SQUARING A NUMBER
Model CAA-10

Multiply a number by itself.

Example:

13.52 × 13.52 = 182.7904

Program:

Upper dials	4	Tab	0
Keyboard	4	Slide	0
Lower dials	8		

Step 1. Set 13.52 on the keyboard at 4th decimal. Depress **and hold down** the SET UP key until set up action is complete. (When SET UP key is held down, number on keyboard does not clear). Depress the CLEAR MULT key.

Result in lower dials 182.7904

SQUARING A NUMBER
Model CAA-10-3-S

Multiply a number by itself.

Example:

13.52 × 13.52 = 182.7904

Program:

Upper dials	4	Tab	0
Keyboard	4	Slide	0
Lower dials	8	Squaring Lock	down

Step 1. Set 13.52 on the keyboard at the 4th decimal. Depress the SET UP key. Depress the CLEAR MULT key.

Result in lower dials 182.7904

Note: If squaring lock is up, set-up action is normal and squaring can be accomplished by the same method as used on the CAA Model explained above.

FINDING A RECIPROCAL

The reciprocal of a number is 1 divided by that number.

Example:

$1 \div 144 = .006944$

Program:

Upper dials	0
Keyboard	0
Lower dials	0

Step 1. Set 1 on the extreme left of the keyboard and depress the DIVD TAB. Set 144 on the extreme left of the keyboard and depress the DIV key.

Result: Upper dials 694444444* = .006944 when pointed off correctly

*All zeros in the upper dials to the left of the first significant digit are to be ignored and the reciprocal pointed off in accordance with the following rule:

"To point off a reciprocal correctly, prefix to the reciprocal one less zero than there were whole numbers in the original number.

If the original number is a decimal, point off as many whole numbers plus one in the reciprocal as there were decimal numbers in the original number".

EXPLANATION OF SYMBOLS

SYMBOLS USED IN THIS BOOK		OTHER COMMONLY USED SYMBOLS *
x	An individual variate	X
$\bar{x}$	Arithmetic mean, or average, of x variates	$\overline{X}$
y	An individual variate	
$\bar{y}$	Arithmetic mean, or average, of y variates	
N	Number of variates	n
Σ	Sum of	S
f	Actual frequency	F
x_o	Provisional mean	G.M., A, Xd
C	Class interval	i, k, c, I
u	Unit deviation of a variate from its arithmetic mean	c, d,
$\bar{u}$	Arithmetic mean, or average, of u values	
H. M.	Harmonic mean	H, H_m
G. M.	Geometric mean	G, G_m
R	Range	
X_{max}	Highest variate in a distribution	
X_{min}	Lowest variate in a distribution	
Q	Quartile deviation	Q. D.
Q_1	First quartile	
Q_3	Third quartile	
σ_x	Standard deviation of x variates	s
σ_y	Standard deviation of y variates	
σ_u	Standard deviation of u values	
α_3	Measure of skewness	Sk, g_1
α_4	Measure of kurtosis	Ku, g_2
r	Coefficient of correlation	
S_x	Standard error of estimate of x variates	s
S_y	Standard error of estimate of y variates	
χ^2	Chi square	
F	Theoretical frequency	
m	Slope of a line	
b	Point where line crosses the ordinate axis	

*Monroe recognizes that a standard set of symbols does not exist in the field of statistics. For that reason, we have included this list of commonly used symbols so that the user may readily see the connection between the symbols used in this book and those which he may be using.

PERCENT INCREASE OR DECREASE

Data:

1952	*1951*	*Per cent Increase*	*Per cent Decrease*
325,426	213,513	52.41%	
316,574	457,933		30.87%

Program:

Upper dials	4 - 2	Tab	5
Keyboard	4	Slide	0
Lower dials	8 - 4 - 2	Change Lever	X

Step 1. Set 325,426 (1952 figure) on keyboard at 4th decimal and depress DIVD TAB. Set 213,513 (1951 figure) on keyboard at 4th decimal and a 1 in the extreme right hand column of the keyboard. Depress DIV key.

Result: Upper dials (4th decimal) 1.52.41 which is an increase of 52.41% because a 1 precedes the increase in the upper dials.

Step 2. Set 316,574 (1952 figure) on keyboard at 4th decimal and depress DIVD TAB key. Set 457,933 (1951 figure) on keyboard at 4th decimal and a 1 in the extreme right hand column of the keyboard. Depress DIV key.

Result: Lower dials (4th decimal) 30.87 which is a decrease because no 1 precedes the result in the upper dials.

Thus all increases are read in the upper dials since a 1 will precede the numbers in the upper dials and all decreases are read in the lower dials since no 1 precedes the numbers in the upper dials.

PER CENT INCREASE OR DECREASE

CAA Statistical Model

Data:

1952	*1951*	*Per cent Increase*	*Per cent Decrease*
325,426	213,513	52.41%	
316,574	457,933		30.87%

Program:

Upper dials	4 - 2	Tab	5
Keyboard	2	Change Lever locked	X
Lower dials	6		

Step 1. Set 325,426 (1952 figure) on keyboard at 2nd decimal and depress DIVD TAB. Set 213,513 (1951 figure) on keyboard at 2nd decimal and depress DIV key.

Result: Left upper dials (4th decimal) 1.52.41 which is an increase since a 1 precedes the figure in the left upper dials.

Step 2. Set 316,574 (1952 figure) on keyboard at 2nd decimal and depress DIVD TAB. Set 457,933 (1951 figure) on the keyboard at 2nd decimal and depress DIV key.

Result: Right upper dials (4th decimal) 30.87%* which is a decrease since there is no 1 preceding the figure in the left upper dials.

Thus all increases are read in the left upper dials when a 1 precedes the figures in the left upper dials and all decreases in the right upper dials when no 1 precedes the figures in the left upper dials.

*The row of 9's which precede this result are to be ignored.

PERCENTAGE DISTRIBUTION USING RECIPROCAL

Data:

Group	*Value*	*Per cent*
A	1226	13.70
B	1697	18.96
C	2436	27.21
D	3593	40.14
	8952	

Program:

Upper dials	10
Keyboard	4
Lower dials	14 - 12

Step 1. Set 1 on the extreme left of the keyboard and depress the DIVD TAB. Set 8952 (group total) on the keyboard at the extreme left of the keyboard and depress the DIV key.

Result: Upper dials 111706881 when correctly pointed off as reciprocal = .0001117068

Step 2. Set .0001117068 on the extreme left of the keyboard and depress the SET UP key. Lock the reciprocal (.0001117068) in the SET UP dials by moving "C"onstant Lever Lock down. Set 1226 (value group A) on the keyboard at the 4th decimal and depress the CLEAR MULT key.

Result: Lower dials at 14th decimal .1369525368 or 13.70 (Per cent that Group A is of total)

Step 3. Set 1697 (value group B) on the keyboard at decimal and depress the CLEAR MULT key.

Result: Lower dials at 14th decimal .1895664396 or 18.96 (Per cent that group B is of total)

Step 4. Continue in the same manner for groups C and D.

Results: .2721177648 or 27.21 (Per cent group C is of total)
.4013625324 or 40.14 (Per cent group D is of total)

Note: As the last multiplication is performed move "C"onstant Lever Lock up in order to clear the SET UP dials of the reciprocal that is being used as a constant multiplier.

PERCENT AND ACCUMULATED PERCENT

Data:

Group	*Value*	*Percent*	*Accumulated Percent*
A	1226	13.69	13.69
B	1697	18.96	32.65
C	2436	27.21	59.86
D	3593	40.14	100.00
	8952		

Program:

Upper dials	4 - 2	Change Lever locked	÷
Keyboard	8 - 4 - 0	Tab	5
Lower dials	4	Slide	4
		Lower dials locked	

Step 1. Set 1 in the first right hand column of keyboard and depress SET UP key. Move Constant lever down.

Step 2. Lock 8952 (total value) on keyboard at zero decimal by holding down clear key as these digits are being set. Set 1226 (Group A) on keyboard at 4th decimal and depress CLEAR MULT key. Depress DIV key.

Result: Upper dials (4th decimal) 13.69 percent that Group A is of total

Step 3. Continue in the same manner for Groups B, C and D.

Results: Upper dials (4th decimal) 18.96 Group B
27.21 Group C
40.14 Group D

Note: If the work has been done correctly, the lower dials will clear to zero upon completion of the last division.

Step 4. Clear locked keyboard by depressing different keys in the columns in which the digits are locked. Depress clear key. Set 13.69 (percent Group A) on keyboard at 4th decimal and depress PLUS BAR. Set 18.96 (percent Group B) on keyboard at 4th decimal and depress PLUS BAR.

Result: Lower dials (4th decimal) 32.65 percent that Groups A and B are of total.

Step 5. Add Group C and D to lower dials total in the same manner.

Results: 59.86 (Group A+B+C)
100.00 (Group A+B+C+D)

PERCENT AND ACCUMULATED PERCENT

CAA Statistical Model

Data:

Group	*Value*	*Percent*	*Accumulated Percent*
A	1226	13.69	13.69
B	1697	18.96	32.65
C	2436	27.21	59.86
D	3593	40.14	100.00
	8952		

Program:

Upper dials (right & left)	4 - 2	Tab	5
Keyboard	4	Slide	0
Lower dials	8	Change lever	X
		Upper and lower dials locked	

Be sure upper and lower dials are clear before locking.

Step 1. Set 1226 (Group A) on the keyboard at decimal and depress DIVD TAB. Set 8952 (Group Total) on keyboard at decimal and depress DIV key.

Results:	Left upper dials at 4th decimal	13.69 percent Group A is of total value
	Right upper dials at 4th decimal	13.69 accumulated percent Group A is of total value

Step 2. Set 1697 (Group B) on the keyboard at decimal and depress DIVD TAB. Set 8952 (Group Total) on keyboard at decimal and depress DIV key.

Results:	Left upper dials at 4th decimal	18.96 percent Group B is of total value
	Right upper dials at 4th decimal	32.65 accumulated percent Group A & B is of total value

Step 3. Continue in the same manner for Groups C and D.

Results:	Group C	27.21%	left upper dials
	Group A + B + C	59.86%	right upper dials
	Group D	40.14%	left upper dials
	Group A + B + C + D	100.00%	right upper dials

If the work has been done correctly, the lower dials will clear to zero (0).

CUMULATIVE FREQUENCY

Data:

Class Limits	*Class Mark*	*f*
30 - 39	34.5	3
40 - 49	44.5	11
50 - 59	54.5	23
60 - 69	64.5	35
70 - 79	74.5	24
80 - 89	84.5	13
90 - 99	94.5	4
		N = 113

Boundary	*Cum f*
29.5	0
39.5	3
49.5	14
59.5	37
69.5	72
79.5	96
89.5	109
99.5	113

Program:

Upper dials	0
Keyboard	0
Lower dials	0

Non-repeat key depressed

Step 1. Set 3 (f_1) on the right of the keyboard and depress PLUS BAR.

Result: Lower dials: 3 (f_1)

Step 2. Note 3 (f_1) on paper. Set 11 (f_2) on the right of the keyboard and depress the PLUS BAR.

Result: Lower dials: 14 ($f_1 + f_2$)

Step 3. Note 14 ($f_1 + f_2$) on paper. Continue in the same way until all values for *Cum f* have been calculated and noted on paper.

Result: Lower dials: 113 ($f_1 + f_2 + f_3 + ... + f_7 = N$)

PERCENTAGE CUMULATIVE FREQUENCY

Data:

Class Limits	*Class Mark*	*f*
30 - 39	34.5	3
40 - 49	44.5	11
50 - 59	54.5	23
60 - 69	64.5	35
70 - 79	74.5	24
80 - 89	84.5	13
90 - 99	94.5	4
		N = 113

Boundary	*Cum f*	*% Cum f*
29.5	0	0
39.5	3	2.65
49.5	14	12.38
59.5	37	32.74
69.5	72	63.71
79.5	96	84.95
89.5	109	96.46
99.5	113	100.00

Program:

Upper dials	2	Tab	5
Keyboard	4		
Lower dials	6		

Step 1. Set 3 (Cum f_1) on the keyboard at the decimal and depress DIVD TAB. Set 113 (N) on the keyboard at the decimal and depress DIV key.

Result: Upper dials at decimal: 2.65 (% Cum f_1)

Step 2. Note 2.65 (% Cum f_1) on paper. Set 14 (Cum f_2) on the keyboard at the decimal and depress DIVD TAB. Set 113 (N) on the keyboard at the decimal and depress DIV key.

Result: Upper dials at decimal: 12.38% (% Cum f_2)

Step 3. Continue in the same way until all the % Cum f have been calculated and noted on paper.

Result: Upper dials: 100.00 (% Cum f_7)

ARITHMETIC MEAN – UNGROUPED DATA

Formula:

$$\bar{x} = \frac{1}{N}\Sigma x = \frac{x_1 + x_2 + \ldots + x_n}{N}$$

Data:

45, 56, 58, 76, 62, 33, 55, 61, 37, 63

Program:

Upper dials	4	Non-repeat key depressed	
Keyboard	0	Tab	0
Lower dials	4	Slide	0

Step 1. With the carriage in the 5th position, set 45 (x_1) on the extreme right of the keyboard and depress the PLUS BAR.

Result: Upper dials at decimal : 1
Lower dials at decimal : 45 (x_1)

Step 2. Set 56 (x_2) on the extreme right of the keyboard and depress PLUS BAR.

Result: Upper dials at decimal: 2 (number of items added)
Lower dials at decimal: 101 ($x_1 + x_2$)

Step 3. Continue in this manner until all the values have been added.

Result: Lower dials at decimal: 546 (Σx)
Upper dials at decimal: 10 (N)

Step 4. Copy 10 from the upper dials to the right of the keyboard and clear upper dials. Shift carriage to align left digit of lower dials figure with the left digit of the keyboard figure. Depress DIV key.

Result: Upper dials at decimal: 54.6 ($\bar{x}$)

ARITHMETIC MEAN – GROUPED DATA

Formula:

$$\bar{x} = \frac{1}{N}\Sigma fx = \frac{f_1x_1 + f_2x_2 + \ldots\ldots\ldots + f_nx_n}{N}$$

Data:

Class Limits	*Class Mark (x)*	*f*
30 - 39	34.5	3
40 - 49	44.5	11
50 - 59	54.5	23
60 - 69	64.5	35
70 - 79	74.5	24
80 - 89	84.5	13
90 - 99	94.5	4
		N = 113

Program:

Upper dials	4	Tab	0
Keyboard	4	Change Lever	X
Lower dials	8	Upper and Lower dials locked	

Be sure that the upper and lower dials are clear before locking.

Step 1. Set 3 (f_1) on keyboard at decimal and depress SET UP key. Set 34.5 (x_1 class mark) on keyboard at decimal and depress CLEAR MULT key.

Result: Upper dials at decimal: 3 (f_1)
Lower dials at decimal: 103.5 (f_1x_1)

Step 2. Set 11 (f_2) on keyboard at decimal and depress SET UP key. Set 44.5 (x_2) on keyboard at decimal and depress CLEAR MULT key.

Result: Upper dials at decimal: 14 ($f_1 + f_2$)
Lower dials at decimal: 593 ($f_1 x_1 + f_2 x_2$)

Step 3. Continue in the same manner for the remaining x and f values.

Result: Upper dials at decimal: 113 ($\Sigma f = N$)
Lower dials at decimal: 7368.5 (Σfx)

Step 4. Unlock upper and lower dials and copy 113 from upper dials to keyboard at decimal. Clear upper dials. Shift carriage so that the left digit of lower dials figure aligns with the left digit of keyboard figure. Depress DIV key.

Result: Upper dials at decimal: 65.2079 ($\bar{x}$)

ARITHMETIC MEAN - SHORT METHOD

Formula:

$$\bar{x} = C\bar{u} + x_o \quad \text{where } \bar{u} = \frac{1}{N}\Sigma fu$$
$$\text{and } u = \frac{x - x_o}{C}$$

Data:

Class limits	*Class Mark (x)*	*Frequency*	*u*	*fu*
30 - 39	34.5	3	-3	
40 - 49	44.5	11	-2	
50 - 59	54.5	23	-1	
60 - 69	64.5	35	0	
70 - 79	74.5	24	1	
80 - 89	84.5	13	2	
90 - 99	94.5	4	3	
		N = 113		8

Program:

Upper dials	4-0	Tab	0
Keyboard	4-0	Slide	0
Lower dials	4	Change lever	÷
		Upper and lower dials locked	

Be sure upper and lower dials are clear before locking.

Step 1. Set 3 (f_1) on extreme right of keyboard and depress SET UP key. Set 3 (u_1) on keyboard at 4th decimal and depress NEG MULT key.

Result: Upper dials at zero decimal: 3 (f_1)
Lower dials at 4th decimal: 99....91 (- $f_1 u_1$)

Step 2. Continue in the same manner for the remainder of the -u items. Move change lever to X position. Set 35 (f_4) on extreme right of keyboard and depress SET UP key. Depress CLEAR MULT key.

Result: Upper dials at zero decimal: 72 ($f_1 + f_2 + f_3 + f_4$)
Lower dials at 4th decimal: 99....946 ($-f_1 u_1 - f_2 u_2 - f_3 u_3 + f_4 u_4$)

Step 3. Set 24 (f_5) on extreme right of keyboard and depress SET UP key. Set 1 (u_5) at 4th decimal and depress CLEAR MULT key.

Result: Upper dials at zero decimal: 96 ($f_1 + f_2 + f_3 + f_4 + f_5$)
Lower dials at 4th decimal: 99....970 ($-f_1 u_1 - f_2 u_2 - f_3 u_3 + f_4 u_4 + f_5 u_5$)

Step 4. Continue in the same manner for the remaining f and u values.

Result: Upper dials at zero decimal: 113 (Σf)
Lower dials at 4th decimal: 8 (Σfu)*

*If this result is negative, i.e. a row of 9's precedes the figure, depress Repeat key and copy figure directly to keyboard. Depress MINUS BAR twice and correct negative figure will appear. Before beginning Step 5, clear keyboard and copy correct negative figure to it. Unlock and clear lower dials, depress PLUS BAR and then proceed as in Step 5. Then, in Step 6, use NEG MULT instead of CLEAR MULT, but clear lower dials before doing so. As a result of this, shift carriage to first position before beginning Step 7.

Step 5. Copy 113 to extreme right of keyboard. Unlock upper and lower dials and clear upper dials only. Shift carriage so that left digit in lower dials figure aligns with left digit of keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: .0707 ($\bar{u}$)

Step 6. Set 10 (C) on the extreme right of keyboard and depress SET UP key. Copy .0707 from upper dials to keyboard at 4th decimal and depress CLEAR MULT key.

Result: Lower dials at 4th decimal: .7070 ($C\,\bar{u}$)

Step 7. Set 64.5 (x_o) on keyboard at 4th decimal and depress PLUS BAR.

Result: Lower dials at 4th decimal: 65.2070 ($\bar{x}$)

ARITHMETIC MEAN - SHORT METHOD (PREFERRED)

Formula:

$$\bar{x} = C\bar{u} + x_o \quad \text{where } \bar{u} = \frac{1}{N}\Sigma fu$$

$$\text{and } u = \frac{x - x_o}{C}$$

Data:

Class Limits	*Class Mark (x)*	*f*	*u*	*fu*
30 - 39	34.5	3	0	
40 - 49	44.5	11	1	
50 - 59	54.5	23	2	
60 - 69	64.5	35	3	
70 - 79	74.5	24	4	
80 - 89	84.5	13	5	
90 - 99	94.5	4	6	
		N = 113		347

Program:

Upper dials	4 - 0	Tab	0
Keyboard	4 - 0	Slide	0
Lower dials	4	Change Lever	X
		Upper and lower dials locked	

Be sure that upper and lower dials are clear before locking.

Step 1. Set 3 (f_1) on extreme right of keyboard and depress SET UP key. Depress CLEAR MULT key.

Result: Upper dials at zero decimal: 3 (f_1)
Lower dials at 4th decimal: 0 ($f_1\,u_1$)

Step 2. Set 11 (f_2) on extreme right of keyboard and depress SET UP key. Set 1 (u_2) on keyboard at 4th decimal and depress CLEAR MULT key.

Result: Upper dials at zero decimal: 14 ($f_1 + f_2$)
Lower dials at 4th decimal: 11 ($f_1u_1 + f_2u_2$)

Step 3. Continue in the same manner for the remaining f and u values.

Result: Upper dials at zero decimal: 113 (Σf)
Lower dials at 4th decimal: 347 (Σfu)

Step 4. Copy 113 from upper dials to extreme right of keyboard. Unlock both upper and lower dials and clear upper dials only. Shift carriage so that left digit of lower dials figure aligns with the left digit of the keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: 3.0707 ($\bar{u}$)

Step 5. Set 10 (C) on extreme right of keyboard and depress SET UP key. Copy 3.0707 from upper dials to keyboard at 4th decimal and depress CLEAR MULT key.

Result: Lower dials at 4th decimal: 30.7070 ($C\bar{u}$)

Step 6. Set 34.5 (x_o) on keyboard at decimal and depress PLUS BAR.

Result: Lower dials: 65.2070 ($\bar{x}$)

HARMONIC MEAN - UNGROUPED DATA

Formula:

$$\text{H. M.} = \frac{N}{\Sigma\frac{1}{x}} = \frac{N}{\left(\frac{1}{x_1} + \frac{1}{x_2} + \ldots\ldots\ldots\ldots + \frac{1}{x_n}\right)}$$

Data:

x = 45, 56, 58, 76, 62, 33, 55, 61, 37, 63

Program:

Upper dials	5	Tab	6
Keyboard	5	Slide	0
Lower dials	10	Upper dials locked	

Be sure that the upper dials are clear before locking.

Step 1. Set 1 on the keyboard at 5th decimal and depress DIVD TAB. Set 45 (x_1) on keyboard at 5th decimal and depress DIV key.

Result: Upper dials at 5th decimal: $.02222\left(\frac{1}{x_1}\right)$

Step 2. Set 1 on the keyboard at 5th decimal and depress DIVD TAB. Set 56 (x_2) on keyboard at 5th decimal and depress DIV key.

Result: Upper dials at 5th decimal: $.04007\left(\frac{1}{x_1}+\frac{1}{x_2}\right)$

Step 3. Continue in the same manner for the remaining x values.

Result: Upper dials at 5th decimal: $.19434\left(\Sigma\frac{1}{x}\right)$

Step 4. Set 10 (N) on keyboard at 5th decimal and depress DIVD TAB. Copy .19434 from upper dials to keyboard at 5th decimal. Unlock and clear upper dials only. Shift carriage so that left digit of lower dials figure aligns with left digit of keyboard figure. Depress DIV key.

Result: Upper dials: 51.45621 (H. M.)

HARMONIC MEAN - GROUPED DATA

Formula:

$$\text{H. M.} = \frac{N}{\Sigma\frac{f}{x}} = \frac{N}{\frac{f_1}{x_1}+\frac{f_2}{x_2}+\ldots\ldots+\frac{f_n}{x_n}}$$

Data:

x	f
40	3
50	6
60	10
70	8
80	4
	N = 31

Program:

Upper dials	5	Tab	6
Keyboard	5	Slide	0
Lower dials	10	Upper dials locked	

Be sure that upper dials are clear before locking.

Step 1. Set 3 (f_1) on keyboard at decimal and depress DIVD TAB. Set 40 (x_1) at decimal and depress DIV key.

Result: Upper dials at 5th decimal: $.07500\left(\frac{f_1}{x_1}\right)$

Step 2. Continue in the same manner for the remaining x and f values.

Result: Upper dials at 5th decimal: $.52594\left(\Sigma\frac{f}{x}\right)$

Step 3. Set 31 (N) on keyboard at decimal and depress DIVD TAB. Copy .52594 from upper dials to keyboard at decimal. Unlock and clear upper dials. Shift carriage so that left digit of lower dials figure aligns with left digit of keyboard figure. Depress DIV key.

Result: Upper dials at 5th decimal: 58.94208 (H. M.)

GEOMETRIC MEAN

Formula:

$$G.M. = (x_1 \cdot x_2 \ldots\ldots\ldots x_n)^{\frac{1}{N}}$$

$$\text{Log } G.M. = \frac{1}{N} \log (x_1 \cdot x_2 \ldots\ldots\ldots x_n)$$

Data:

$x = 3, 5, 9, 17, 33$

$N = 5$

Program:

Upper dials	5	Tab	6
Keyboard	5	Slide	5
Lower dials	10		

Step 1. Set 3 (x_1) on the keyboard at 5th decimal and depress the SET UP key.
Set 5 (x_2) on the keyboard at 5th decimal and depress the CLEAR MULT key.

Result: Lower dials at 10th decimal: 15 ($x_1 \cdot x_2$)

Step 2. TRANSFER. Set 9 (x_3) on the keyboard at the 5th decimal and depress the CLEAR MULT key.

Result: Lower dials at 10th decimal: 135 ($x_1 \cdot x_2 \cdot x_3$)

Step 3. Continue in the same manner for the remaining values of x.

Result: Lower dials at 10th decimal: 75,735 ($x_1 \cdot x_2 \cdot x_3 \cdot x_4 \cdot x_5$)

Step 4. From logarithmic tables determine log of 75,735 which is 4.87930. Set 4.87930 (log 75,735) on the keyboard at decimal. Depress upper shift bar once. Depress the DIVD TAB. Set 5 (N) on the keyboard and depress the DIV key.

Result: Upper dials at 5th decimal: $.97586\left[\frac{\text{Log } (x_1 \ldots\ldots x_5)}{N}\right]$

Step 5. From logarithmic tables determine antilog of .97586 which is 9.4593 (G. M.)

MEDIAN

Formula:

$$y = y_1 + \frac{C(x - x_1)}{f}$$

where

$x = \frac{N}{2}$

x_1 = Cum f closest to but less than x

y = median

y_1 = Boundary corresponding to x_1

C = class interval

f = Frequency within the interval of which y_1 is the lower boundary.

Data:

Class Limits	*Class Mark*	*f*	*Boundary*	*Cum f*
			29.5	0
30 - 39	34.5	3	39.5	3
40 - 49	44.5	11	49.5	14
50 - 59	54.5	23	59.5	37
60 - 69	64.5	35	69.5	72
70 - 79	74.5	24	79.5	96
80 - 89	84.5	13	89.5	109
90 - 99	94.5	4	99.5	113
		N = 113		

Program:

Upper dials	5	Tab	6
Keyboard	5	Slide	5
Lower dials	10		

Step 1. Set .5 on the keyboard at 5th decimal and depress SET UP key. Set 113 (N) on the keyboard at 5th decimal and depress CLEAR MULT key.

Result: Lower dials at 10th decimal: 56.5 ($x = \frac{N}{2}$)

Step 2. Set 37 (x_1) on the keyboard at 5th decimal and depress MINUS BAR.

Result: Lower dials at 10th decimal: 19.5 ($x - x_1$)

Step 3. TRANSFER. Set 10 (C) on the keyboard at 5th decimal and depress CLEAR MULT key.

Result: Lower dials at 10th decimal: 195 $[C(x - x_1)]$

Step 4. Clear upper dials. Set 35 (f) on the keyboard at 5th decimal and depress DIV key.

Result: Upper dials at 5th decimal: 5.57142 $\left[\frac{C(x - x_1)}{f}\right]$

Step 5. Set 59.5 (y_1) on the keyboard at 5th decimal and depress SET UP key. Depress ACC MULT key.

Result: Upper dials at 5th decimal: 65.07142 (y)

RANGE

Formula:

$$R = X_{max} - X_{min}$$

Data:

45, 56, 58, 76, 62, 33, 55, 61, 37, 63

Program:

Upper dials	0	Non-repeat key depressed
Keyboard	0	
Lower dials	0	

Step 1. With the carriage in the first position, set 76 (X_{max}) on the right of the keyboard and depress the PLUS BAR.

Result: Lower dials: 76(X_{max})

Step 2. Set 33 (X_{min}) on the right of the keyboard and depress the MINUS BAR.

Result: Lower dials: 43 (R)

QUARTILE DEVIATION

Formula:

$$Q = \frac{Q_3 - Q_1}{2}$$

where Q_1 and Q_3 are found from the data and method for finding the Median where x is equal to $\frac{N}{4}$ and $\frac{3N}{4}$ respectively.

Data:

$Q_1 = 55.70$

$Q_3 = 74.81$

Program:

Upper dials	5
Keyboard	5
Lower dials	10

Step 1. Shift the carriage so that the lower dial decimal at 10 aligns with the keyboard decimal at 5. Set 74.81 (Q_3) on the keyboard at the 5th decimal and depress PLUS BAR. Set 55.70 (Q_1) on the keyboard at the 5th decimal and depress the MINUS BAR.

Result: Lower dials (10th decimal) 19.11 ($Q_3 - Q_1$)

Step 2. Set 2 on the keyboard at the 5th decimal and depress the DIV key.

Result: Upper dials (5th decimal) 9.555 (Q)

STANDARD DEVIATION – UNGROUPED DATA

Formula:

$$\sigma_x = \sqrt{\frac{\Sigma x^2}{N} - \bar{x}^2} \qquad \text{where } \bar{x} = \frac{\Sigma x}{N}$$

Data:

x = 45, 56, 58, 76, 62, 33, 55, 61, 37, 63

Program:

Upper dials	6 - 3	Tab	0
Keyboard	6 - 3	Slide	0
Lower dials	12 - 9	Upper and lower dials locked	

Note: On the CAA Statistical Model, the Veeder Counter should be set at zero. Be sure that the upper and lower dials are clear before locking.

Step 1. Set 45 (x_1) on the extreme right of the keyboard. Depress SET UP key and hold for squaring. (For CAA-Statistical Model, see *Note 1.*) Depress CLEAR MULT key. Set 56 (x_2) on the right of the keyboard. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. Continue in the same manner for all the remaining values of x.

Results: Upper dials at zero decimal: 546 (Σx)
Lower dials at zero decimal: 31318 (Σx^2)

Note: On the CAA-Statistical Model, the Veeder Counter will read 10 (N).

Step 2. Note 31,318 (Σx^2) on paper. Copy 546 (Σx) from the upper dials to the right of the keyboard. Unlock upper and lower dials. (For CAA-Statistical Model, see *Note 2*). Depress DIVD TAB. Set 10 (N) on the keyboard at 3rd decimal. Depress DIV key.

Result: Upper dials at 6th decimal: 54.6 ($\bar{x}$)

Step 3. Copy 54.6 from the upper dials to the keyboard at the 6th decimal. Depress SET UP key. Set 31,318 (x^2) on the right of the keyboard, disregarding the decimal. Depress DIVD TAB. Set 10 (N) on the keyboard at 3rd decimal. Depress DIV key.

Result: Upper dials at 6th decimal: 3131.8 $\left(\frac{\Sigma x^2}{N}\right)$

Step 4. Copy 3131.8 from the upper dials to the keyboard at the 6th decimal. Shift carriage so that the lower dial decimal at 12 aligns with the keyboard decimal at 6. Depress PLUS BAR. Shift carriage back to the 1st position. Copy 54.6 from the Multiplier Set-up dials to the keyboard at 6th decimal. Depress NEG MULT key.

Result: Lower dials at 12th decimal: 150.64 (σ_x^2)

Step 5. Extract the square root by the method set forth in Appendix I.

Result: 12.27354881 (σ_x)

Note 1: On CAA-Statistical Model, move squaring lock down and depress SET UP key. Do *not* hold SET UP key down.

Note 2: On CAA-Statistical Model, move squaring lock up to restore normal action of SET UP key.

STANDARD DEVIATION – GROUPED DATA

Formula:

$$\sigma_x = C\sigma_u \text{ where } \sigma_u = \sqrt{\frac{\Sigma f u^2}{N} - \bar{u}^2}$$

$$\bar{x} = C\bar{u} + x_o \qquad \bar{u} = \frac{\Sigma fu}{N}, \; u = \frac{x - x_o}{C}$$

Data:

Class Limits	*Class Mark*	*f*	*u*	*fu*	fu^2
30 - 39	34.5	3	-3		
40 - 49	44.5	11	-2		
50 - 59	54.5	23	-1		
60 - 69	64.5	35	0		
70 - 79	74.5	24	1		
80 - 89	84.5	13	2		
90 - 99	94.5	4	3		
		N = 113		8	206

Program:

Upper dials	7 - 1	Slide	8
Keyboard	7 - 2	Upper dials locked	
Lower dials	14 - 9 - 1	Lower dials Split-Locked	9 - 10

Be sure the upper and lower dials are clear before locking.

Step 1. Set 3 (f_1) on the keyboard at the 7th decimal. Depress SET UP key. Set 3 (u_1) on the keyboard at 2nd decimal. Depress ACC MULT key. TRANSFER. Set 3 (u_1) on the extreme right of the keyboard. Depress CLEAR MULT key. Continue in this way until the O value of u is reached.

Results: Upper dials at 7th decimal: 37 ($f_1 + f_2 + f_3$)
Upper dials at 1st decimal: 54 (Σfu, only negative values of u)
Lower dials at 1st decimal: 94 ($f_1u_1^2 + f_2u_2^2 + f_3u_3^2$)

Step 2. Note the 54 on paper as a minus value. With the keyboard clear, by means of the MINUS BAR, clear the 54 from the right of the upper dials. Set 35 (f when u = o) on the keyboard at 7th decimal. Depress SET UP key. Depress CLEAR MULT key. Continue as in Step 1 for the remainder of the *f* and *u* values.

Results: Upper dials at 7th decimal: 113 ($\Sigma f = N$)
Upper dials at 1st decimal: 62 (Σfu, only positive values of u)
Lower dials at 1st decimal: 206 (Σfu^2)

Step 3. Note 206 (Σfu^2) on paper. Copy 62 (Σfu for positive values of u) from upper dials to the right of the keyboard.* Unlock and clear upper and lower dials. Depress PLUS BAR. Set 54 (Σfu for negative values of u) on the keyboard and depress MINUS BAR.

Result: Lower dials: 8 (Σfu) which is a positive value.

*If the sum of the negative *fu* values is greater than the sum of the positive *fu* values, set the negative *fu* value on the keyboard first and subtract from it the positive *fu* value. The answer will be negative and must be remembered as such for all steps involving *fu*. Therefore, in Step 4, $\bar{u}$ will be a negative figure and is copied to paper as such, and in Step 9 it will be necessary to clear both upper and lower dials before beginning this Step and then multiply by depressing the NEG MULT key.

Step 4. Set 8 (Σfu) on the right of the keyboard. Depress DIVD TAB. Set 113 (N) on the keyboard at 2nd decimal. Depress DIV key.

Result: Upper dials at 7th decimal: .0707964 ($\bar{u}$)

Step 5. Copy .0707964 ($\bar{u}$) from the upper dials to the keyboard at the 7th decimal and also note on paper. Depress SET UP key. Set 206 (Σfu^2) on the right of the keyboard disregarding the decimal marker. Depress DIVD TAB. Set 113 (N) on the keyboard at the 2nd decimal. Depress DIV key.

Result: Upper dials: $1.8230088\left(\frac{\Sigma fu^2}{N}\right)$

Step 6. Clear lower dials only. Copy 1.8230088 from the upper dials to the keyboard at the 7th decimal. Shift the carriage so that the lower dial decimal at 14 aligns with the keyboard decimal at 7. Depress PLUS BAR. Shift the carriage to the 1st position. Copy .0707964 ($\bar{u}$) from the multiplier set-up dials to the keyboard at the 7th decimal. Depress NEG MULT key.

Result: Lower dials at 14th decimal: 1.817997 (σ_u^2)

Step 7. Extract the square root of 1.817997 by the method set forth in the appendix of this book.

Result: 1.3483312 (σ_u) which is copied to paper.

Step 8. Set 10 (C) on the keyboard at 2nd decimal. Depress SET UP key. Set 1.3483312 (σ) on the keyboard at the 7th decimal. Depress CLEAR MULT key.

Result: Lower dials: 13.483312 (σ_x)

Step 9. Set 10 (C) on the keyboard at 2nd decimal. Depress SET UP key. Copy .0707964 (u) from paper to the keyboard at the 7th decimal. Depress CLEAR MULT key. Shift carriage so that the lower dial decimal at 9 aligns with the keyboard decimal at 7. Set 64.5 (x_o) on the keyboard at the 7th decimal. Depress PLUS BAR.

Result: Lower dials: 65.207964 ($\bar{x}$)

STANDARD DEVIATION – GROUPED DATA (PREFERRED)

Formula:

$$\sigma_x = C\sigma_u \quad \text{where} \quad \sigma_u = \sqrt{\frac{\Sigma fu^2}{N} - \bar{u}^2}$$

$$\bar{x} = C\bar{u} + x_o \qquad \bar{u} = \frac{\Sigma fu}{N},\ u = \frac{x - x_o}{C}$$

Data:

Class Limits	*Class Mark*	f	u	fu	fu^2
30 - 39	34.5	3	0		
40 - 49	44.5	11	1		
50 - 59	54.5	23	2		
60 - 69	64.5	35	3		
70 - 79	74.5	24	4		
80 - 89	84.5	13	5		
90 - 99	94.5	4	6		
		N = 113		347	1271

Program:

Upper dials	7 - 1	Slide	8
Keyboard	7 - 2	Upper dials locked	
Lower dials	14 - 9 - 1	Lower dials split-locked	9 - 10

Be sure that the upper and lower dials are clear before locking.

Step 1. Set 3 (f_1) on the keyboard at the 7th decimal and depress SET UP key. Depress CLEAR MULT key.

Result: Upper dials at 7th decimal: 3 (f_1)

Step 2. Set 11 (f_2) on the keyboard at the 7th decimal. Depress SET UP key. Set 1 (u_2) on the keyboard at 2nd decimal. Depress ACC MULT key. TRANSFER. Set 1 (u_2) in the first right hand column of the keyboard. Depress CLEAR MULT key.

Result: Upper dials at 7th decimal: 14 ($f_1 + f_2$)
Upper dials at 1st decimal: 11 (f_2u_2)
Lower dials at 1st decimal: 11 ($f_2u_2^2$)

Step 3. Continue in the same manner for the remaining values of f and u.

Results: Upper dials at 7th decimal: 113 ($\Sigma f=N$)
Upper dials at 1st decimal: 347 (Σfu)
Lower dials at 1st decimal: 1271 (Σfu^2)

Step 4. Note 1271 (Σfu^2) on paper. Copy 347 (Σfu) from the upper dials to the extreme right of the keyboard. Unlock upper and lower dials. Depress DIVD TAB. Set 113 (N) on the keyboard at the 2nd decimal. Depress DIV key.

Result: Upper dials at 7th decimal: 3.0707964 ($\bar{u}$)

Step 5. Copy 3.0707964 ($\bar{u}$) from the upper dials to paper and to the keyboard at the 7th decimal. Depress SET UP key. Set 1271 (Σfu^2) on the extreme right of the keyboard. Depress DIVD TAB. Set 113 (N) on the keyboard at the 2nd decimal. Depress DIV key.

Result: Upper dials at 7th decimal: 11.2477876 $\left(\frac{\Sigma fu^2}{N}\right)$

Step 6. Clear lower dials only. Copy 11.2477876 from the upper dials to the keyboard at 7th decimal. Shift the carriage so that the lower dials decimal at 14 aligns with the keyboard decimal at 7. Depress the PLUS BAR. Shift the carriage to the 1st position. Copy 3.0707964 from the Multiplier Set-up dials to the keyboard at the 7th decimal. Depress NEG MULT key.

Result: Lower dials at 14th decimal: 1.817997 (σ_u^2)

Step 7. Extract the square root of 1.817997 by the method set forth in Appendix I of this book.

Result: 1.3483312 (σ_u)

Step 8. Set 10 (C) on the keyboard at the 2nd decimal. Depress SET UP key. Set 1.3483312 (σ_u) on the keyboard at the 7th decimal. Depress CLEAR MULT key.

Result: Lower dials at 9th decimal: 13.483312 (σ_x)

Step 9. Set 10 (C) on the keyboard at the 2nd decimal. Depress SET UP key. Set 3.0707964 ($\bar{u}$) on the keyboard at the 7th decimal. Depress CLEAR MULT key. Shift the carriage so that the lower dial decimal at 9 aligns with the keyboard decimal at 7. Set 34.5 (x_o) on the keyboard at the 7th decimal. Depress PLUS BAR.

Result: 65.207964 ($\bar{x}$)

SKEWNESS

Formula:

$$\alpha_3 = \frac{\frac{1}{N}\Sigma f(x - \bar{x})^3}{\sigma_x^3} = \frac{\frac{C}{N}\Sigma f(u - \bar{u})^3}{C\sigma_u^3}$$

$$= \frac{\frac{\Sigma fu^3}{N} - 3\frac{\Sigma fu^2}{N} \cdot \frac{\Sigma fu}{N} + 2\left(\frac{\Sigma fu}{N}\right)^3}{\sigma_u^3}$$

Data:

Class Mark	*f*	*u*	*fu*	*fu²*	*fu³*
34.5	3	0			0
44.5	11	1			11
54.5	23	2			184
64.5	35	3			945
74.5	24	4			1536
84.5	13	5			1625
94.5	4	6			864
	N = 113		347	1271	5165

$\sigma_u = 1.3483$ $\quad \frac{\Sigma fu}{N} = 3.0707$ $\quad \frac{\Sigma fu^2}{N} = 11.2477$

Program:

Upper dials	4	Tab	5
Keyboard	4	Slide	4
Lower dials	8	Non-entry	UP
		Upper dials	locked

Be sure upper dials are clear before locking.

Step 1. Set 11(f_2) on keyboard at decimal and depress SET UP key. Set 1 (u_2) on keyboard at decimal and depress CLEAR MULT key. TRANSFER. Set 1 (u_2) on keyboard at decimal and depress CLEAR MULT key. TRANSFER. Set 1 (u_2) on keyboard at decimal and depress CLEAR MULT key.

Result: Lower dials at 8th decimal: 11 ($f_2u_2^3$)

Copy result to paper to be used in solving for α_4. Set 1 on keyboard at decimal and shift carriage to align left digits of lower dials figure and keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: 11 ($f_2u_2^3$)

Step 2. Set 23 (f_3) on keyboard at decimal and depress SET UP key. Set 2 (u_3) on keyboard and depress CLEAR MULT key. TRANSFER. Set 2 (u_3) on keyboard and depress CLEAR MULT key. TRANSFER. Set 2 (u_3) on keyboard. Depress CLEAR MULT key.

Result: Lower dials at 8th decimal: 184 ($f_3u_3^3$)

Copy result to paper to be used in solving for a_4. Set 1 on keyboard at decimal and shift carriage to align left digits of lower dials figure and keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: 195 ($f_2u_2^3 + f_3u_3^3$)

Step 3. Continue in the same manner for the rest of the variates.

Result: Upper dials at 4th decimal: 5165 (Σfu^3)

Step 4. Unlock upper dials and copy 5165 to keyboard at decimal. Depress DIVD TAB. Set 113 (N) on keyboard at decimal. Align left digits of lower dials and keyboard figures. Depress DIV key.

Result: Upper dials at 4th decimal: $45.7079\left(\frac{\Sigma fu^3}{N}\right)$

Step 5. Copy result to paper. Set 1.3483 (σ_u) on keyboard at decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. TRANSFER. Set 1.3483 (σ_u) on keyboard at decimal and depress CLEAR MULT key.

Result: Lower dials at 8th decimal: 2.4510 (σ_u^3)

Step 6. Copy result to paper. Set $3.0707\left(\frac{\Sigma fu}{N}\right)$ on keyboard at decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. TRANSFER. Set 3.0707 on keyboard at decimal and depress CLEAR MULT key. TRANSFER. Set 2 on keyboard at decimal and depress CLEAR MULT key.

Result: Lower dials: $57.9078\left[2\left(\frac{\Sigma fu}{N}\right)^3\right]$

Step 7. Copy result to paper. Set $3.0707\left(\frac{\Sigma fu}{N}\right)$ on keyboard at decimal and depress SET UP key. Set $11.2477\left(\frac{\Sigma fu^2}{N}\right)$ on keyboard and depress CLEAR MULT key. TRANSFER. Set 3 on keyboard at decimal and depress NEG MULT key.

Result: Lower dials: $99....9896.3851\left(-3\frac{\Sigma fu^2}{N}\cdot\frac{\Sigma fu}{N}\right)$

Step 8. Shift carriage so that lower dial decimal at 8 aligns with keyboard decimal at 4. Set $57.9078\left[2\left(\frac{\Sigma fu}{N}\right)^3\right]$ on keyboard at decimal and depress PLUS BAR. Set $45.7079\left(\frac{\Sigma fu^3}{N}\right)$ on keyboard at decimal and depress PLUS BAR.

Result: Lower dials at 8th decimal: .0008

Step 9. Set 2.4510 (σ_u^3) on keyboard at decimal and depress DIV key.

Result: Upper dials: .0003 (a_3)

KURTOSIS

Formula:

$$\alpha_4 = \frac{\frac{1}{N}\Sigma f(x - \bar{x})^4}{\sigma_x^4} = \frac{\frac{C}{N}\Sigma f(u - \bar{u})^4}{C\sigma_u^4}$$

$$\frac{\Sigma\frac{fu^4}{N} - 4\Sigma\frac{fu^3}{N}\Sigma\frac{fu}{N} + 6\Sigma\frac{fu^2}{N}\left(\Sigma\frac{fu}{N}\right)^2 - 3\left(\Sigma\frac{fu}{N}\right)^4}{\sigma_u^4}$$

Data:

Class Mark	*f*	*u*	*fu*	fu^2	fu^3	fu^4
34.5	3	0	0	0	0	
44.5	11	1	11	11	11	
54.5	23	2	46	92	184	
64.5	35	3	105	315	945	
74.5	24	4	96	384	1536	
84.5	13	5	65	325	1625	
94.5	4	6	24	144	864	
	113		347	1271	5165	22667

$\sigma_u = 1.3483$

$\Sigma\frac{fu}{N} = 3.0707$ $\Sigma\frac{fu^2}{N} = 11.2477$ $\Sigma\frac{fu^3}{N} = 45.7079$

Program:

Upper dials	4	Tab	5
Keyboard	4	Slide	4
Lower dials	8	Upper dials locked	
		Non-entry key	UP

Be sure that the upper dials are clear before locking.

Step 1. Set 11 ($f_2u_2^3$) on the keyboard at the decimal and depress the SET UP key. Set 1 (u_2) on the keyboard at the decimal and depress the CLEAR MULT key. Set 1 on the keyboard at the decimal and shift the carriage to align left digits of lower dial figure and keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: $11(f_2u_2^4)$

Step 2. Set 184 ($f_3u_3^3$) on the keyboard at the decimal and depress the SET UP key. Set 2 (u_3) on the keyboard at decimal and depress the CLEAR MULT key. Set 1 on the keyboard at the decimal and align left digits of lower dial and keyboard figures. Depress the DIV key.

Result: Upper dials at 4th decimal: 379 ($f_2u_2^4 + f_3u_3^4$)

Step 3. Continue in the same manner for the remainder of the variates.

Result: Upper dials at 4th decimal: 22,667 (Σfu^4)

Step 4. Unlock the upper dials and copy 22,667(Σfu^4) to the keyboard at the decimal. Depress the DIVD TAB key. Set 113 (N) on the keyboard at the decimal. Align the left digits of lower dials and keyboard figures. Depress the DIV key.

Result: Upper dials at 4th decimal: 200.5929 $\left(\Sigma\frac{fu^4}{N}\right)$

Step 5. Copy the result to paper. Set 1.3483 (σ_u) on the keyboard at the decimal. Depress the SET UP key and hold for squaring. Depress the CLEAR MULT key. Copy the result, 1.8179 to the keyboard. Depress the SET UP key and hold for squaring. Depress the CLEAR MULT key.

Result: Lower dials at 8th decimal: 3.3047 ($\sigma_u{}^4$)

Step 6. Copy the result to paper. Set 3.0707 $\left(\Sigma\frac{fu}{N}\right)$ on the keyboard and depress and hold the SET UP key for squaring. Depress the CLEAR MULT key. Copy the result, 9.4291, to the keyboard and depress and hold SET UP key for squaring. Depress the CLEAR MULT key. TRANSFER. Set 3 on the keyboard at the decimal and depress the CLEAR MULT key.

Result: Lower dials at 8th decimal: 266.7237 $\left[3\left(\Sigma\frac{fu}{N}\right)^4\right]$

Step 7. Copy the result to paper. Set 3.0707 $\left(\Sigma\frac{fu}{N}\right)$ on the keyboard at the decimal. Depress and hold the SET UP key for squaring. Depress the CLEAR MULT key. TRANSFER. Set 11.2477 $\left(\Sigma\frac{fu^2}{N}\right)$ on the keyboard at the decimal and depress the CLEAR MULT key. TRANSFER. Set 6 on the keyboard at the decimal and depress the CLEAR MULT key.

Result: Lower dials at 8th decimal: 636.3336 $\left[6\Sigma\frac{fu^2}{N}\left(\Sigma\frac{fu}{N}\right)^2\right]$

Step 8. Copy the result to paper. Set 3.0707 $\left(\Sigma\frac{fu}{N}\right)$ on the keyboard at the decimal and depress the SET UP key. Set 45.7079 $\left(\Sigma\frac{fu^3}{N}\right)$ on the keyboard at the decimal and depress the CLEAR MULT key. TRANSFER. Set 4 on the keyboard and depress the NEG MULT key.

Result: Lower dials at 8th decimal: 99....9438.5792 $\left(4\Sigma\frac{fu^3}{N}\Sigma\frac{fu}{N}\right)$

Align decimal at 8 in the lower dials with the keyboard decimal at 4. Set 200.5929 $\left(\frac{\Sigma fu^4}{N}\right)$ on the keyboard and depress the PLUS BAR. Set 266.7237 $\left[3\left(\frac{\Sigma fu}{N}\right)^4\right]$ on the keyboard and depress the MINUS BAR. Set 636.3336 $\left[6\Sigma\frac{fu^2}{N}\cdot\left(\Sigma\frac{fu}{N}\right)^2\right]$ on the keyboard at the decimal and depress the PLUS BAR.

Result: Lower dials at 8th decimal: 8.7820

$$\left[\Sigma\frac{fu^4}{N} - 4\Sigma\frac{fu^3}{N}\Sigma\frac{fu}{N} + 6\Sigma\frac{fu^2}{N}\left(\Sigma\frac{fu}{N}\right)^2 - 3\left(\Sigma\frac{fu}{N}\right)^4\right]$$

Step 9. Set 3.3047 ($\sigma_u{}^4$) on the keyboard and depress the DIV key.

Result: Upper dials at 4th decimal: 2.6574 (a_4)

ACCUMULATIONS IN LINEAR CORRELATIONS

Required Accumulations

$\Sigma x \quad \Sigma y \quad \Sigma xy \quad \Sigma x^2 \quad \Sigma y^2$

Data:

x - 23, 24, 27, 27, 28, 29, 27, 29, 31, 30, 30, 32, 34, 35, 35, 36, 37, 38, 31, 24,

y - 19, 20, 21, 22, 25, 28, 23, 21, 26, 29, 32, 28, 31, 28, 30, 32, 31, 33, 24, 21.

Program:

Upper dials	7 - 0	Upper and lower dials locked	
Keyboard	7 - 0	Tab	0
Lower dials	14 - 7 - 0	Slide	0

Note: On the Monroe Statistical Model, the Veeder Counter should be set at zero (0).

Be sure that upper and lower dials are clear before locking.

Step 1. Set 23 (x_1) on the keyboard at the 7th decimal and 19 (y_1) on the extreme right of the keyboard. Depress and hold SET UP key for squaring.* Depress CLEAR MULT key.

Results: Upper dials at 7th decimal: 23 (x_1)
Upper dials at 0 decimal: 19 (y_1)
Lower dials at 14th decimal: 529 (x_1^2)
Lower dials at 7th decimal: 874 ($2x_1y_1$)
Lower dials at 0 decimal: 361 (y_1^2)

Note: On the Monroe Statistical Model, the Veeder Counter will read "1". Left upper dials will read 23 (x_1) and 19 (y_1).

Step 2. Continue in the same manner for the remainder of the x and y values.

Results: Upper dials at 7th decimal: 607 (Σx)
Upper dials at 0 decimal: 524 (Σy)
Lower dials at 14th decimal: 18795 (Σx^2)
Lower dials at 7th decimal: 32474 ($\Sigma 2xy$)
Lower dials at 0 decimal: 14126 (Σy^2)

Copy to paper Σx, Σy, Σx^2, Σy^2.

Note: On Monroe Statistical Model, the Veeder Counter will read 20 (N). Left upper dials will read 24 (x_{20}) and 21 (y_{20}).

Step 3. Shift the carriage so that the lower dials decimal at 7 aligns with the keyboard decimal at zero (0). Mentally divide 32474 ($\Sigma 2xy$) by 2 and set the result (16237) on the keyboard at the extreme right. Depress the repeat key and MINUS BAR.

Result: Lower dials at 7th decimal: 16237 (Σxy)

To prove that this has been done correctly, note that the figures on the keyboard and in the lower dials are exactly the same. If the figures are not the same, depress the PLUS BAR, thus regaining the original $\Sigma 2xy$ figure. Repeat Step 3 to obtain correct Σxy figure.

*On Monroe Statistical Model CAA-10-3-S, move squaring lock down and depress SET UP key. Do not hold SET UP key depressed. To restore normal action of the SET UP key when accumulations are completed, move squaring lock up.

FORMULA SUBSTITUTION FOR LINEAR CORRELATION

Formula:

$$r = \frac{\frac{\Sigma xy}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y} \qquad \text{where} \quad \sigma_x = \sqrt{\frac{1}{N}\Sigma x^2 - \bar{x}^2} \qquad \text{and} \quad \sigma_y = \sqrt{\frac{1}{N}\Sigma y^2 - \bar{y}^2}$$

Data:

$\Sigma x = 607$ $\quad \Sigma y = 524$ $\quad \Sigma xy = 16{,}237$

$\Sigma x^2 = 18{,}795$ $\quad \Sigma y^2 = 14{,}126$ $\quad N = 20$

Program:

Upper dials	5	Tab	9
Keyboard	5 - 2	Slide	0
Lower dials	10	Change Lever	X

Computing $\sigma_x, \sigma_y, \bar{x}, \bar{y}$

All results are to be copied to paper.

Step 1. Set 607 (Σx) on keyboard at 2nd decimal and depress DIVD TAB. Set 20 (N) on keyboard at 5th decimal and depress DIV key.

Result: Upper dials at 5th decimal: 30.35 ($\bar{x}$)

Step 2. Copy 30.35 to keyboard at 5th decimal and depress SET UP key. Set 18,795 (Σx^2) on keyboard at 2nd decimal and depress DIVD TAB. Set 20 (N) on keyboard at 5th decimal and depress DIV key.

Result: Upper dials at 5th decimal: 939.75 ($\Sigma \frac{x^2}{N}$)

Step 3. Copy 939.75 from upper dials to keyboard at 5th decimal. Clear upper and lower dials and shift carriage to align lower dials decimal at 10 with keyboard decimal at 5. Depress PLUS BAR. Shift carriage to first position. Set 30.35 ($\bar{x}$) on keyboard at 5th decimal, and depress NEG MULT key.

Result: Lower dials at 10th decimal: 18.6275 (σ_x^2)

Step 4. Extract square root by method set forth in appendix I.

Result: 4.31596 (σ_x)

Step 5. Repeat Step 1 through 4 for y values.

$\bar{y} = 26.2$ $\quad \sigma_y^2 = 19.86$ $\quad \sigma_y = 4.45646$ $\quad \Sigma \frac{y^2}{N} = 706.3$

Computing r

Step 6. Set 4.45646 (σ_y) on keyboard at 5th decimal and depress SET UP key. Set 4.31596 (σ_x) on keyboard at 5th decimal and depress CLEAR MULT key.

Result: Lower dials at 10th decimal: 19.23390 ($\sigma_x \sigma_y$) Copy result to paper.

Step 7. Set 16,237 (Σxy) on keyboard at 2nd decimal and depress DIVD TAB. Set 20 (N) on keyboard at 5th decimal and depress DIV key.

Result: Upper dials at 5th decimal: 811.85 $\left(\Sigma \frac{xy}{N}\right)$

Step 8. Copy 811.85 from upper dials to keyboard at 5th decimal. Clear upper and lower dials. Shift carriage to align lower dials decimal at 10 with keyboard decimal at 5. Depress PLUS BAR.

Step 9. Set 30.35 ($\bar{x}$) on keyboard at 5th decimal and depress SET UP key. Set 26.2 ($\bar{y}$) on keyboard at 5th decimal and depress NEG MULT key.

Result: Lower dials: 16.68 $\left(\Sigma \frac{xy}{N} - \bar{x}\,\bar{y}\right)$

Step 10. Clear upper dials only. Set 19.23390 ($\sigma_x \sigma_y$) on keyboard at 5th decimal and depress DIV key.

Result: Upper dials at 5th decimal: .86721 (r)

REGRESSION

Formulas:

y on x, $y - \bar{y} = \frac{r\sigma_y}{\sigma_x}(x - \bar{x})$ (1) or y on x, $y = \frac{r\sigma_y}{\sigma_x}x - \frac{r\sigma_y}{\sigma_x}\bar{x} + \bar{y}$ (1A)

x on y, $x - \bar{x} = \frac{r\sigma_x}{\sigma_y}(y - \bar{y})$ (2) or x on y, $x = \frac{r\sigma_x}{\sigma_y}y - \frac{r\sigma_x}{\sigma_y}\bar{y} + \bar{x}$ (2A)

Data:

$\bar{x} = 30.35$ $\sigma_x = 4.31596$ $r = .86721$

$\bar{y} = 26.2$ $\sigma_y = 4.45646$

Program:

Upper dials	5	Tab	6
Keyboard	5	Slide	5
Lower dials	10		

Step 1. Set 4.45646 (σ_y) on keyboard at decimal and depress DIVD TAB. Set 4.31595 (σ_x) on keyboard at decimal and depress DIV key.

Result: Upper dials at 5th decimal: 1.03255 $\left(\frac{\sigma_y}{\sigma_x}\right)$

Step 2. Copy 1.03255 from upper dials to keyboard at decimal and depress SET UP key. Set .86721 (r) on keyboard at decimal and depress CLEAR MULT key.

Result: Lower dials at 10th decimal: .89543 $\left(\frac{r\sigma_y}{\sigma_x}\right)$

Coefficient of x which is copied to paper.

Step 3. TRANSFER. Set 30.35 ($\bar{x}$) on keyboard at decimal and depress NEG MULT key. Shift carriage so that the lower dial decimal at 10 aligns with the keyboard decimal at 5. Set 26.2 ($\bar{y}$) on keyboard at decimal and depress PLUS BAR.

Result: Lower dials at 10th decimal: 9....99.02369*

(This is the complement of the true negative figure.)

Step 4. Set repeat key and copy 9....99.02369 to keyboard and depress MINUS BAR twice.

Result: Lower dials 10th decimal : $.97631\left(\frac{r\sigma_y x + y}{\sigma_x}\right)$

Substituting these results in equation 1A gives y = .89543 x - .97631

Step 5. Solve for the regression line of x on y (equations 2 and 2A) in the same manner.

Result: x = .83986 y + 8.34567

*If this result is a positive figure, Step 4 is omitted and the result is substituted directly into equation 1A.

FINDING POINTS ON THE LINES OF REGRESSION

Formulas:

y = .89543x - .97631 x = .83986y + 8.34567

Data:

Observed (x)	*Regression Line (y)*	*Regression Line (x)*	*Observed (y)*
5	3.5	12.54	5
10	7.98	16.74	10
15	12.46	20.94	15
20	16.93	25.14	20
25	21.41	29.34	25
30	25.89	33.54	30

Program:

Upper dials	5	Repeat key depressed	
Keyboard	5	Tab	6
Lower dials	10		

Step 1. Shift carriage so that the lower dial decimal at 10 aligns with the keyboard decimal at 5. Set .97631 at decimal and depress MINUS BAR. Clear upper dials and keyboard. Set .89543 (coefficient of x) on keyboard at 5th decimal and multiply semiautomatically by holding down the PLUS BAR until 5 (x_1) appears in the upper dials.

Result: Lower dials at 10th decimal: 3.50084 (y when x = 5)

Step 2. Hold down PLUS BAR until 10 appears in upper dials at 5th decimal.

Result: Lower dials at 10th decimal: 7.9779 (y when x = 10)

Continue in the same manner for x = 15, 20, 25, 30.

Step 3. Solve for x in equation (2) by clearing upper and lower dials and keyboard. Set 8.34567 on keyboard and depress PLUS BAR. Clear upper dials and keyboard. Set .83986 (coefficient of y) on keyboard at decimal and multiply semiautomatically by holding down PLUS BAR, until 5 (y_1) appears in upper dials at 5th decimal.

Result: Lower dials at 10th decimal: 12.54497 (x when y = 5)

Continue in the same manner for y = 10, 15, 20, 25, 30.

STANDARD ERROR OF ESTIMATES

Formula:

$$S_y = \sigma_y \sqrt{1 - r^2}$$

$$S_x = \sigma_x \sqrt{1 - r^2}$$

Data:

$r = .86721$, $\sigma_y = 4.45646$, $\sigma_x = 4.31596$

Program:

Upper dials	5	Tab	0
Keyboard	5	Slide	0
Lower dials	10	Change Lever	X

Be sure the upper and lower dials are clear before starting problems.

Step 1. Set .86721 (r) on the keyboard at the decimal. Depress and hold the SET UP key for squaring. Depress the NEG MULT key. Shift the carriage so that the lower dials decimal at 10 aligns with the keyboard decimal at 5. Set 1 on the keyboard at decimal and depress the PLUS BAR.

Result: Lower dials at 10th decimal: $.2479468159\ (1 - r^2)$

Step 2. Extract the square root of $.2479468159\ (1 - r^2)$ by the method set forth in the Appendix.

Result: $.49794\ (\sqrt{1 - r^2})$

Copy result to paper to be used in solving for S_x.

Step 3. Set $.49794\ (\sqrt{1 - r^2})$ on the keyboard at decimal and depress the SET UP key. Set 4.45646 (σ_y) on the keyboard and depress the CLEAR MULT key.

Result: Lower dials at 10th decimal: 2.21905 (S_y)

Step 4. Set $.49794\ (\sqrt{1 - r^2})$ on the keyboard at decimal and depress the SET UP key. Set 4.31596 (σ_x) on the keyboard at decimal and depress the CLEAR MULT key.

Result: Lower dials at 10th decimal: 2.14909 (S_x)

ACCUMULATIONS IN MULTIPLE CORRELATION

Required Accumulations:

Σx	Σy	Σz	Σxy
Σx^2	Σy^2	Σz^2	Σyz
			Σxz

Data:

(x)	*(y)*	*(z)*
21	62	39
23	61	38
25	64	26
27	61	29

Program:

Upper dials	7 - 0	Upper dials locked
Keyboard	7 - 0	Lower dials locked
Lower dials	14 - 7 - 0	

Be sure upper and lower dials are clear before locking.

Note: On the Monroe Statistical Model, the Veeder Counter should be set at zero.

$(x + z)^2 = x^2 + 2xz + z^2$

Step 1. Set 21 (x_1) on the keyboard at the 7th decimal, and 39 (z_1) on the extreme right of the keyboard. Depress SET UP key, and hold depressed for squaring.* Depress CLEAR MULT key.

Results: Upper dials at 7th decimal: 21 (x_1)
Upper dials at 0 decimal: 39 (z_1)
Lower dials at 14th decimal: 441 (x_1^2)
Lower dials at 0 decimal: 1521 (z_1^2)
Lower dials at 7th decimal: 1638 ($2x_1z_1$)

Note: On the Monroe Statistical Model, a 1 will appear in the Veeder Counter. Left upper dials will read 21 (x_1) and 39 (z_1).

Step 2. Set 23 (x_2) on the keyboard at the 7th decimal and 38 (z_2) at the zero decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. Continue the same operation for the balance of the x and z values.

Results: Upper dials at 7th decimal: 96 (Σx)
Upper dials at 0 decimal: 132 (Σz)
Lower dials at 14th decimal: 2324 (Σx^2)
Lower dials at 0 decimal: 4482 (Σz^2)
Lower dials at 7th decimal: 6252 ($\Sigma 2xz$)

Note: On the Monroe Statistical Model, the Veeder Counter will read 4 (N). Left upper dials will read 27 (x_4) and 29 (z_4).

*On the Monroe Statistical Model CAA-10-3-S, move the Squaring lock down and depress the SET UP key. Do not hold SET UP key depressed. To restore normal action of the SET UP key when the accumulations are completed, move the Squaring lock up.

Step 3. Copy to paper Σx, Σz, Σx^2, Σz^2. Shift the carriage so that the lower dials decimal at 7 aligns with the keyboard decimal at zero. Mentally divide 6252 ($\Sigma 2xz$) by 2 and set the result (3126) on the extreme right of the keyboard. Depress the repeat key and MINUS BAR.

Result: Lower dials at 7th decimal: 3126 (Σxz)

Copy result to paper. To prove that this has been done correctly, note that the figures on the keyboard and in the lower dials are the same. If they are not, depress the PLUS BAR, thus regaining the original figure for $\Sigma 2xz$. Repeat Step 3 to obtain correct figure for Σxz.

$(x + y)(y + z) = xy + (xz + y^2) + yz$

Step 4. Unlock, clear and relock both the upper and lower dials. *Note:* On the Monroe Statistical Model, reset Veeder Counter to zero (0). Set 21 (x_1) on the keyboard at the 7th decimal and 62 (y_1) at the zero decimal. Depress SET UP key. Set 62 (y_1) on the keyboard at the 7th decimal and 39 (z_1) at the zero decimal. Depress CLEAR MULT key.

Results: Upper dials at 7th decimal: 21 (x_1)
Upper dials at 0 decimal: 62 (y_1)
Lower dials at 14th decimal: 1302 (x_1y_1)
Lower dials at 0 decimal: 2418 (y_1z_1)
Lower dials at 7th decimal: 4663 ($x_1z_1 + y_1^2$)

Note: On the Monroe Statistical Model, the Veeder Counter will read "1". Left upper dials will read 21 (x_1) and 62 (y_1).

Step 5. Set 23 (x_2) on the keyboard at the 7th decimal and 61 (y_2) at the zero decimal. Depress SET UP key. Set 61 (y_2) on the keyboard at the 7th decimal and 38 (z_2) at the zero decimal. Depress CLEAR MULT key. Continue the same operation for the balance of the x, y and z values.

Results: Upper dials at 7th decimal: 96 (Σx)
Upper dials at 0 decimal: 248 (Σy)
Lower dials at 14th decimal: 5952 (Σxy)
Lower dials at 0 decimal: 8169 (Σyz)
Lower dials at 7th decimal: 18508 ($\Sigma xz + \Sigma y^2$)

Note: On the Monroe Statistical Model, the Veeder Counter will read 4 (N). Left upper dials will read 27 (x_4) and 61 (y_4).

Step 6. Copy to paper Σy, Σxy, Σyz. Shift carriage so lower dials decimal at 7 aligns with keyboard decimal at zero. Set 3126 (Σxz) from Step 3 on the right of the keyboard. Depress the MINUS BAR.

Result: Lower dials at 7th decimal: 15382 (Σy^2)

CHI-SQUARE

Formula:

$$\chi^2 = \Sigma\frac{(f - F)^2}{F}$$

Data:

Actual Frequency	*Theoretical Frequency*	*Chi-Square values*
(f)	(F)	
15	12	
46	54	
25	24	
14	10	
20	12	
52	54	
20	24	
8	10	
200	200	10.05

Program:

Upper dials	5	Tab	6
Keyboard	5	Slide	5
Lower dials	10 - 5	Non-entry	UP
		Upper dials locked	
		Non-repeat key depressed	

Be sure the upper dials are clear before locking.

Step 1. Set 15 (f_1) on the keyboard at the 5th decimal and depress the PLUS BAR. Set 12 (F) on the keyboard at the 5th decimal and depress the MINUS BAR.

Result: Lower dials at 5th decimal: 3 ($f_1 - F_1$)

Step 2. Copy 3($f_1 - F_1$)to the keyboard at the 5th decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key.

Result: Lower dials at 10th decimal: 9 $(f_1 - F_1)^2$

Step 3. Set 12(F_1) on the keyboard at the 5th decimal. Depress DIV key.

Result: Upper dials at 5th decimal: $.75\left[\frac{(f_1 - F_1)^2}{F_1}\right]$

Step 4. Clear lower dials and continue as in Steps 1-3 for the remaining variables.
(*Note:* The difference is obtained by subtracting the smaller from the larger.)

Result: Upper dials at 5th decimal: $10.05\left[\Sigma\frac{(f - F)^2}{F}\right]$

ANALYSIS OF VARIANCE

Data:

SAMPLE	ANALYST A	ANALYST B	ANALYST C	ANALYST D	TOTALS OF ROWS
I	7.1	16.0	10.7	13.4	47.2 ⑦
II	14.2	15.4	15.1	20.9	65.6 ⑧
III	8.5	16.5	9.6	13.6	48.2 ⑨
TOTALS OF COLUMNS	29.8 ①	47.9 ②	35.4 ③	47.9 ④	161.0 ⑤ ⑩

	$\frac{(\Sigma X)^2}{N}$	SUM OF SQUARES	D OF F	UNBIASED ESTIMATE
Σx^2 2325.700 ④	2160.083 ⑫	Total 165.617 ⑬		
$\Sigma(TC)^2/R$ 2243.340 ⑥	2160.083	Columns 83.257 ⑭	(C-1) 3	27.752 ⑲
$\Sigma(TR)^2/C$ 2213.610 ⑪	2160.083	Rows 53.527 ⑮	(R-1) 2	26.764 ⑱
Interaction or residual = T − C − R 28.833 = 165.617 − 83.257 − 53.527		Interaction 28.833 ⑯	(N-1)-(R-1)-(C-1) 6	4.806 ⑰

Number of elements, N = 12; number of columns, C = 4; number of rows, R = 3

The circled numbers that follow certain amounts indicate the sequence in which results are obtained and noted on working papers by the operator; each circled number also corresponds to the step number in the instructions that follow.

Program:

Upper dials	4	Upper dials locked
Keyboard	4	Lower dials locked
Lower dials	8 - 4	

Be sure upper and lower dials are clear before locking.

Note: On the Monroe Statistical Model, the Veeder Counter must be set at zero.

Step 1. Column A: Set 7.1 on the keyboard at the 4th decimal. Depress SET UP key and hold for squaring.* Depress CLEAR MULT key. Continue in the same manner until the remaining values in column A have been squared and accumulated.

Result: Upper dials at 4th decimal: 29.8 ①
Lower dials at 8th decimal: 324.3 (Σx^2 to this point)

*On the Monroe CAA 10-3-S (Statistical Model), move Squaring Lock down and depress SET UP key. Do *not* hold SET UP key depressed. To restore normal action of SET UP key when accumulations are completed, move squaring lock UP.

Step 2. Note total for Column A. Unlock, clear, and relock the upper dials only. Column B: Set 16.0 on the keyboard at the 4th decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. Continue in the same manner until all of the values in Column B have been squared and accumulated.

Result: Upper dials at 4th decimal: 47.9 (2)
Lower dials at 8th decimal: 1089.71 (Σx^2 to this point)

Step 3. Note total for Column B. Unlock, clear, and relock upper dials only. Follow the same procedure for the values of Column C.

Result: Upper dials at 4th decimal: 35.4 (3)
Lower dials at 8th decimal: 1524.37 (Σx^2 to this point)

Step 4. Note total for Column C. Unlock, clear, and relock upper dials only. Follow the same procedure for the values of Column D.

Results: Upper dials at 4th decimal: 47.9 (4)
Lower dials at 8th decimal: 2325.7 (4) Σx^2

Note: On the Monroe Statistical Model, the Veeder Counter will read 12 (N).

Step 5. Note total for Column D and Σx^2. Unlock, clear, and relock both the upper and lower dials. Set 29.8(1) on the keyboard at the 4th decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. Set 47.9 (2) on the keyboard at 4th decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. Continue until all of the column totals have been squared and accumulated.

Results: Upper dials at 4th decimal: 161.0 (5) Σx
Lower dials at 8th decimal: 6730.02 (Sums of squares of column totals)

Step 6. Note 161.0 (Σx) from upper dials. Unlock both the upper and lower dials. Clear upper dials only. Set 3.0 (R) on keyboard at 4th decimal. Shift the carriage so that the left digit of the lower dials amount aligns with the digit set on the keyboard. Depress DIV key.

Result: Upper dials at 4th decimal: 2243.34 (6) $\frac{\Sigma (TC)^2}{R}$

Step 7. Note result. Clear the entire machine. Set 7.1 (Row 1 Col. A) on the keyboard at 4th decimal and depress PLUS BAR. Set 16.0 (Row 1 Col. B) on the keyboard at 4th decimal and depress PLUS BAR. Continue adding the remaining values in Row I.

Result: Lower dials at 4th decimal: 47.2 (7)

Step 8. Note result. Clear the entire machine and add, as in Step 7, the values in Row II.

Result: Lower dials at 4th decimal: 65.6 (8)

Step 9. Note result. Clear the machine and add, as in Step 7, the values in Row III.

Result: Lower dials at 4th decimal: 48.2 (9)

Step 10. Note result. Clear the entire machine. Lock both the upper and lower dials. Set 47.2 (Total Row I) on the keyboard at 4th decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. Continue in the same manner – squaring and accumulating the totals for Rows II and III.

Results: Upper dials at 4th decimal: 161.0 (10) Σx

Lower dials at 8th decimal: 8854.44 (Sums of squares for Row totals)

Step 11. Unlock both the upper and lower dials. Clear the upper dials only. Set 4.0 (C) on the keyboard at the 4th decimal. Shift the carriage so that the left digit of the lower dials amount aligns with the digit set on the keyboard. Depress DIV key.

Result: Upper dials at 4th decimal: 2213.61 (11) $\frac{\Sigma (TR)^2}{C}$

Step 12. Note result. Depress TAB STOP at 5. Set 161.0 (Σx) on the keyboard at 4th decimal. Depress SET UP key and hold for squaring. Depress CLEAR MULT key. Set 12.0 (N) on the keyboard at 4th decimal. Clear upper dials only. Shift the carriage so that the left digit of the lower dials figure aligns with the left digit of the keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: 2160.083 (12) $\frac{(\Sigma x)^2}{N}$

Step 13. Clear lower dials only and depress repeat key. Copy 2160.083 from the upper dials to the keyboard at 4th decimal and depress MINUS BAR once. Change keyboard set up to 2325.7 (Σx^2) and depress PLUS BAR once.

Result: Lower dials at 4th decimal: 165.617 (13) (Sums of squares of totals)

Step 14. Note result. Depress MINUS BAR once. Change keyboard set-up to 2243.34 $\frac{\Sigma (TC)^2}{R}$, and depress PLUS BAR once.

Result: Lower dials at 4th decimal: 83.257 (14) (Sums of squares of columns)

Step 15. Note result. Depress MINUS BAR once. Change keyboard set-up to 2213.61 $\frac{\Sigma (TR)^2}{C}$ and depress PLUS BAR once.

Result: Lower dials at 4th decimal: 53.527 (15) (Sums of squares of Rows)

Step 16. Note result. Change keyboard set-up to 165.617 (Sum of squares of total) and depress DIVD TAB. Set 83.257 (Sum of squares of columns) on the keyboard at 4th decimal and depress MINUS BAR. Set 53.527 (Sum of squares of columns) on the keyboard at 4th decimal and depress MINUS BAR.

Result: Lower dials at 8th decimal: 28.833 (16) (Interaction)

Step 17. Clear upper dials only. Set 6.0, (N-1) - (R-1) - (C-1) on the keyboard and depress DIV key.

Result: Upper dials at 4th decimal: 4.8055 or 4.806 (17)

Step 18. Note result. Set 53.527 on keyboard at 4th decimal and depress DIVD TAB. Set 2.0 (R-1) on the keyboard at 4th decimal. Shift the carriage so that the left digit of the lower dial figure aligns with the left digit of the keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: 26.7635 or 26.764 (18)

Step 19. Note result. Set 83.257 on the keyboard at 4th decimal and depress DIVD TAB. Set 3.0 (C-1) on the keyboard at the 4th decimal. Shift the carriage so that the left digit of the lower dial figure aligns with the left digit of the keyboard figure. Depress DIV key.

Result: Upper dials at 4th decimal: 27.7523 or 27.752 (19)

MOVING AVERAGE

Formula:

$$\frac{x_1 + x_2 + x_3}{3}, \frac{x_2 + x_3 + x_4}{3}, \frac{x_3 + x_4 + x_5}{3}, \frac{x_4 + x_5 + x_6}{3}$$

Data:

$x_1 = 1530$ $x_3 = 1425$ $x_5 = 1554$

$x_2 = 1692$ $x_4 = 1704$ $x_6 = 1250$

Program:

Upper dials	1	Tab	5
Keyboard	3	Change Lever	X
Lower dials	4	Upper dials locked	

Be sure upper dials are clear before locking.

Step 1. Set 1530 (x_1) on extreme right of keyboard and depress DIVD TAB. Set 3 on keyboard at 3rd decimal and depress DIV key.

Result: Upper dials at 1st decimal: 510.0 $(\frac{x_1}{3})$

Step 2. Set 1692 (x_2) on extreme right of keyboard and depress DIVD TAB key. Set 3 on keyboard at 3rd decimal and depress DIV key.

Result: Upper dials at 1st decimal: 1074.0 $(\frac{x_1 + x_2}{3})$

Step 3. Set 1425 (x_3) on extreme right of keyboard and depress DIVD TAB key. Set 3 on keyboard at 3rd decimal and depress DIV key.

Result: Upper dials at 1st decimal: 1549.0 $(\frac{x_1 + x_2 + x_3}{3})$

Copy average to paper.

Step 4. Move change lever lock down. Set 1530 (x_1) on extreme right of keyboard and depress DIVD TAB key. Set 3 on keyboard at 3rd decimal and depress DIV key.

Result: Upper dials at 1st decimal: 1039.0 $(\frac{x_2 + x_3}{3})$

Step 5. Move change lever lock up. Set 1704 (x_4) on extreme right of keyboard and depress DIVD TAB key. Set 3 on keyboard at 3rd decimal and depress DIV key.

Result: Upper dials at 1st decimal: 1607 $(\frac{x_2 + x_3 + x_4}{3})$

Copy average to paper.

Step 6. Continue as above for the remaining values; subtract the unneeded values and add the new values to maintain a moving average.

Results: Upper dials at 1st decimal: 1561 $(\frac{x_3 + x_4 + x_5}{3})$

1502.6 $(\frac{x_4 + x_5 + x_6}{3})$

METHOD OF LEAST SQUARES

Formula:

$$y = mx + b \text{ where } m = \frac{N\Sigma xy - \Sigma x \Sigma y}{N\Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{\Sigma x^2 \Sigma y - \Sigma x \Sigma xy}{N\Sigma x^2 - (\Sigma x)^2}$$

Data:

$\Sigma x = 607$ $\Sigma y = 524$ $\Sigma xy = 16237$

$\Sigma x^2 = 18795$ $\Sigma y^2 = 14126$ $N = 20$

The method and data used to find the above accumulations was the same as that used for *Accumulations for Linear Correlations.*

Program:

Upper dials	4		
Keyboard	4	Non-entry	UP
Lower dials	8		

TO SOLVE FOR m

Step 1. Set 20 (N) on the keyboard at the 4th decimal. Depress the SET UP key. Set 18,795 (Σx^2) on the keyboard at the 4th decimal. Depress the CLEAR MULT key.

Results: Lower dials at 8th decimal: 375,900 ($N\Sigma x^2$)

Step 2. Set 607 (Σx) on the keyboard at the 4th decimal. Depress the SET UP key and hold depressed for squaring. Depress the NEG MULT key.

Results: Lower dials at 8th decimal: 7451 ($N\Sigma x^2 - (\Sigma x)^2$)

Step 3. Note 7451 on paper. Set 20 (N) on the keyboard at the 4th decimal. Depress the SET UP key. Set 16,237 (Σxy) on the keyboard at the 4th decimal. Depress the CLEAR MULT key.

Results: Lower dials at 8th decimal: 324,740 ($N\Sigma xy$)

Step 4. Set 607 (Σx) on the keyboard at the 4th decimal. Depress the SET UP key. Set 524 (Σy) on the keyboard at the 4th decimal. Depress the NEG MULT key.*

Results: Lower dials at 8th decimal: 6672 ($N\Sigma xy - \Sigma x \Sigma y$)

Step 5. Set 7451 (previously noted from Step 2) on the keyboard at the 4th decimal. Depress the DIV key.

Results: Upper dials at 4th decimal: .8954 (m)

TO SOLVE FOR b

Step 6. Set 18795 (Σx^2) on the keyboard at the 4th decimal. Depress the SET UP key. Set 524 (Σy) on the keyboard at the 4th decimal. Depress the CLEAR MULT key.

Results: Lower dials at 8th decimal: 9,848,580 ($\Sigma x^2 \Sigma y$)

*If the result of this step is negative, i. e., preceded by all 9's, proceed using the method outlined in Steps 8 and 9.

Step 7. Set 607 (Σx) on the keyboard at the 4th decimal. Depress the SET UP key. Set 16,237 (Σxy) on the keyboard at the 4th decimal. Depress the NEG MULT key.*

Results: Lower dials at 8th decimal: 9.....992721 (complement of $\Sigma x^2 \Sigma y - \Sigma x \Sigma xy$)

Step 8. Shift the carriage so that the lower dials decimal at 8 aligns with the keyboard decimal at 4. Copy 992,721 from the lower dials to the keyboard at the 4th decimal. Depress the repeat key. Depress the MINUS BAR twice.

Results: Lower dials at 8th decimal: 7,279 ($\Sigma x^2 \Sigma y - \Sigma x \Sigma xy$ which is a negative figure)

Step 9. Clear the keyboard only. Copy 7279 from the lower dials to the keyboard at the 4th decimal. Clear the lower dials. Depress the PLUS BAR once. Clear the keyboard. Set 7451 (previously noted from Step 2) on keyboard at 4th decimal. Depress the DIV key.

Results: Upper dials at 4th decimal: -.9769 (b)

Substitute results from Steps 5 and 9 (m and b) in the equation.

Result: $y = .8954x - .9769$

*If the result of this step is positive, proceed as in Step 5.

APPENDIX

MONROE TABLE FOR SQUARE ROOT EVALUATION
ACCURATE TO EIGHT SIGNIFICANT DIGITS

Based upon a method devised by George E. Reynolds, Air Force Cambridge Research Laboratories, expressly for the Monro-matic calculator.

INSTRUCTIONS

Odd and Even Factors

For roots of whole numbers and mixed numbers

When the number of whole number digits is ODD, use the factor in ODD column. When the number of whole number digits is EVEN, use the factor in EVEN column.

For roots of decimal numbers

When the number of zeros preceding the first significant figure is ODD, use the factor in ODD column. When the number of zeros preceding the first significant figure is EVEN, use the factor in EVEN column. When no zeros precede the first significant figure, use the factor in EVEN column.

MONROE METHOD

With the Non-entry key up, set (N) number, root of which is to be found, on the extreme left of the keyboard. (Exception is for odd values between 625 and 9999 which are to have a zero prefixed to them.) Depress the SET UP key and hold to square. Depress the DIVD TAB key. Determine whether the number is odd or even. Select from the proper columns either the smaller or greater of the two factors that most closely approximate the first few digits of the number set on the keyboard. Set the factor on the keyboard. Depress the PLUS BAR. Set the corresponding divide factor on the keyboard. Depress the DIV key. Set 25 on extreme left of keyboard (for odd values from 40804 to 60516 use 025) Depress the ACC MULT key. Copy the upper dials figure to the keyboard. Depress the DIV key. The root appears in the upper dial, accurate to eight significant figures and with an error of less than five in the ninth figure.

POINTING OFF DECIMALS IN ROOTS

Roots of whole numbers and numbers with decimals

Starting at the decimal point in the number the root of which has been found and working to the left, set off the number into groups of two figures each. The number of such two-figure groups will be the number of whole numbers in the root. If the extreme left-hand group consists of only one figure it should be counted as though a complete group.

Roots of decimal numbers

Starting at the decimal point in the number the root of which has been found and working to the right, set off the zeros preceding the first significant figure into groups of two zeros each. The number of such groups will be the number of zeros that should precede the first significant figure in the root. If the last right-hand group consists of only one zero it should NOT be counted as a group. If no zero, or only one, precedes the first significant figure in the decimal number, then no zeros should precede the first significant figure of its root and the decimal point is placed before the first figure.

Example 1

$\sqrt{6942.3214}$

Program:

Upper dials	0	Slide	8
Keyboard	0	Non-entry	UP
Lower dials	0		

Set 6942.3214 on the keyboard at the extreme left. Depress SET UP key and hold to square. Depress DIVD TAB key. Set 692224 (add factor in EVEN column) on left of keyboard and depress PLUS BAR. Set 3328 (corresponding dividing factor) on left of keyboard and depress DIV key. Clear lower dials. Set 25 on left of keyboard and depress ACC MULT key. Copy upper dials figure 4166034074 to keyboard and depress DIV key.

Result: Upper dials 8332059409

Therefore $\sqrt{6942.3214} = 83.32059409$ correct to eight significant digits.

Example 2

$\sqrt{.000003912}$

Set 3912 on extreme left of the keyboard. Depress SET UP key and hold to square. Depress DIVD TAB key. Set 39204 (add factor in ODD column) on left of keyboard and depress PLUS BAR. Set 792 (corresponding dividing factor) on left of keyboard and depress DIV key. Clear lower dials. Set 25 on left of keyboard and depress ACC MULT key. Copy upper dials figure 988939393, disregarding the zero that appears before the first significant figure, to left of keyboard and depress DIV key.

Result: Upper dials 1977877650

Therefore $\sqrt{.000003912} = .001977877650$ correct to eight significant digits.

Example 3

$\sqrt{730.6789}$

Set 07306789 on keyboard at extreme left. Depress SET UP key and hold to square. Depress DIVD TAB key. Set 072900 (add factor ODD column) on left of keyboard and depress PLUS BAR. Set 1080 (corresponding dividing factor) on left of keyboard and depress DIV key. Clear lower dials. Set 25 on left of keyboard and depress ACC MULT key. Copy upper dials figure 1351554537 to left of keyboard and depress DIV key.

Result: Upper dials 2703107286

Therefore $\sqrt{730.6789}$ is 27.03107286 correct to eight significant digits.

$d = 4\sqrt{a}$

ODD

Add	Div.	Add	Div.	
10000	400	33489	732	
10404	408	34596	744	
10816	416	36100	760	
11236	424	37636	776	
11664	432	39204	792	
12100	440	*		
12544	448	40804	808	**
12996	456	42436	824	
13456	464	44100	840	
13924	472	45796	856	
14400	480	47524	872	
14884	488	49284	888	
15376	496	51076	904	
15876	504	52900	920	
16641	516	54756	936	
17424	528	56644	952	
18225	540	58564	968	
19044	552	60516	984	
19881	564	062500	1000	
20736	576	065025	1020	
21609	588	067600	1040	
22500	600	070225	1060	
23409	612	072900	1080	
24336	624	075625	1100	
25281	636	078400	1120	
26244	648	081225	1140	
27225	660	084100	1160	
28224	672	087025	1180	
29241	684	090000	1200	
30276	696	093025	1220	
31329	708	096100	1240	
32400	720	099225	1260	

*When $39204 < N < 40804$ use 39204 for $N < 39996$ and 40804 for $N \geq 39996$.

**For N in this range multiply by 025.

EVEN

Add	Div.	Add	Div.
102400	1280	352836	2376
106276	1304	363609	2412
110224	1328	374544	2448
114244	1352	385641	2484
118336	1376	396900	2520
122500	1400	409600	2560
126736	1424	422500	2600
131044	1448	435600	2640
135424	1472	448900	2680
139876	1496	462400	2720
144400	1520	476100	2760
148996	1544	490000	2800
153664	1568	504100	2840
159201	1596	518400	2880
164836	1624	534361	2924
170569	1652	550564	2968
176400	1680	567009	3012
182329	1708	583696	3056
188356	1736	600625	3100
194481	1764	617796	3144
200704	1792	635209	3188
207025	1820	652864	3232
213444	1848	672400	3280
219961	1876	692224	3328
227529	1908	712336	3376
235225	1940	732736	3424
243049	1972	753424	3472
251001	2004	774400	3520
259081	2036	795664	3568
267289	2068	819025	3620
275625	2100	842724	3672
284089	2132	866761	3724
292681	2164	891136	3776
301401	2196	915849	3828
311364	2232	940900	3880
321489	2268	966289	3932
331776	2304	994009	3988
342225	2340		


CALCULATING • ADDING
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BOOKKEEPING MACHINES